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DESIGNS FOR THE NEW WARSHIPS.

Congress at its last session inserted in the naval bill a provision directing the secretary of the navy to submit to both houses on the first day of the fifty-seventh congress plans for two battleships and two armored cruisers, and also a report on certain questions affecting the construction of war vessels. In accordance with the terms of this provision Secretary Long transmitted to the senate and the house two reports from the naval board on construction. One of these reports explains the plans proposed by the board for the two battleships and two armored cruisers while the other is an exposition of the board's views with reference to the up-to-date armorclad, combining the highest conditions of efficiency in every respect. In expressing its views on the questions submitted to the navy department by congress in regard to the construction of naval vessels, the board places itself on record against sheathing the bottoms of ships, favors Krupp armor, and advocates the installment of guns not heavier than 12-in. caliber. In the opinion of the board the advantages resulting from sheathing are more than offset by the disadvantages. It admits that sheathing and coppering are a partial protection against fouling, but believes that under ordinary conditions the bottoms of vessels can be kept clean by the use of anti-corrosive and anti-fouling paints.

Concerning armor, the board says that both battleships and armored cruisers should carry as much armored protection as is practicable without detriment to their other important features. Eleven inches is the maximum thickness of the armor of the best quality considered necessary or desirable for battleships, and for armored cruisers 6 in. for the heavy part of the main belt, 8 in. for turrets and barbettes and 9 in. for turret port plates. The elliptical balanced turret, with inclined port plates is considered the best.

Twelve-inch guns are the heaviest considered necessary for battleships, with a combination of 7-in. and 8-in. rapid-fire rifles for the intermediate battery. Four 10-in. guns and sixteen 6-in. rapid-fire guns have been selected for the armored cruisers. This, says the board, gives these vessels phenomenal powers of offence, equalled by none in the world, and fits them to take their place in the line of battle if necessary. Torpedo tubes and torpedoes on board armorclads are not regarded as necessary by the board.

The board justifies its reduction of the speed of the new battleships from 19 to 18 knots by the statement that very high speed can only be obtained by a great sacrifice of weight and space without a corresponding gain in efficiency.

The plans for the new armored cruisers contemplate vessels 502 ft. long on the load water line, having a breadth of 78 ft. 8½ in., a trial displacement of about 14,500 tons, a maximum displacement at full load of about 15,959 tons, a maximum draught of about 27 ft. 2 in., a total coal capacity of about 2,000 tons, indicated horse power of 25,000, and trial speed of not less than 22 knots. The armament will consist of four 10-in. rifles, sixteen 6-in., twenty-two 3-in., twelve 3-pounders and fourteen smaller guns. The armored water line belt will be 7 ft. 6 in. wide, having a maximum thickness of 6 in. over the vitals and tapering to 3 in. at the ends. The barbettes for the 10-in. turrets taper from 7 in. to 4 in. in thickness; the turrets of the 10-in. guns are 8 in. thick with 9-in. port plates. The conning tower and its shield are 9 in. thick. Each vessel is designed to carry 854 officers and men.

The battleships are to be 450 ft. long, 76 ft. 8 in. wide, 16,000 tons trial displacement, 17,604 tons maximum displacement, 26 ft. 9 in. maximum draught, will carry 2,200 tons of coal, have an indicated horse power of 16,500 and a trial speed of not less than 18 knots. The battery will consist of four 12-in. guns, eight 8-in. guns, twelve 7-in. guns, twenty 3-in., twelve 3-pounders and eighteen smaller guns. The armor belt is 3 ft. 3 in. wide and tapers from 11 in. amidships to 4 in. at the stem and the stern. The 12-in. barbettes are 10 in. thick and the armor on the 12-in. turrets is 9 in. thick with 11-in. port plates. Quarters are provided for officers and crew numbering 797.

THE PRESIDENT ON MERCHANT MARINE AND NAVY.

The message of President Roosevelt is in its main features a straightforward document. He goes directly to the point in all that he says. However, both the friends and the enemies of American shipping would prefer that he had expressed himself a little more clearly upon the upbuilding of the merchant marine. He says that the merchant marine should be restored to the seas but this, indeed, could be bravely said by anyone. The question is what means should be taken to restore it. His exact words are as follows:

"The condition of the American merchant marine is such as to call for immediate remedial action by the congress. It is discreditable to us as a nation that our merchant marine should be utterly insignificant in comparison to that of other nations which we overtop in other forms of business. We should not longer submit to conditions under which only a trifling portion of our great commerce is carried in our own ships. To remedy this state of things would not merely serve to build up our shipping interests, but it would also result in benefit to all who are interested in the permanent establishment of a wider market for American products, and would provide an auxiliary force for the navy. Ships work for their own countries just as railroads work for their terminal points. Shipping lines, if established to the principal countries with which we have dealings, would be of political as well as commercial benefit. From every standpoint it is unwise for the United States to continue to rely upon the ships of competing nations for the distribution of our goods. It should be made advantageous to carry American goods in American built ships.

"At present American shipping is under certain great disadvantages when put in competition with the shipping of foreign countries. Many of the fast foreign steamships, at a speed of fourteen knots or above, are subsidized; and all our ships, sailing vessels and steamers alike, cargo carriers of slow speed and mail carriers of high speed, have to meet the fact that the original cost of building American ships is greater than is the case abroad; that the wages paid American officers and seamen are very much higher than those paid the officers and seamen of foreign competing countries; and that the standard of living on our ships is far superior to the standard of living on the ships of our commercial rivals. Our government should take such action as will remedy these inequalities. The American merchant marine should be restored to the ocean."

The president is emphatically in favor of steadily increasing the navy not only in ships but in men as well. He does not want ships built merely to be manned when they are needed in actual war. He wants the battleships worn out, if necessary, in practice drills. Upon this point he says:

"We now have seventeen battleships appropriated for, of which nine are completed and have been commissioned for active service. The remaining eight will be ready in from two to four years, but it will take at least that time to recruit and train the men to fight them. It is of vast concern that we have trained crews ready for the vessels by the time they are commissioned. Good ships and good guns are simply good weapons, and the best weapons are useless save in the hands of men who know how to fight with them. The men must be trained and drilled under a thorough and well planned system of progressive instruction, while the recruiting must be carried on with still greater vigor. Every effort must be made to exalt the main function of the officer—the command of men. The leading graduates of the naval academy should be assigned to the combatant branches, the line and marines."

RECORD OF A GREAT SHIP YARD.

It would seem only a few years since the Newport News Ship Building & Dry Dock Co. began the construction of steel vessels at Newport News, Va., and yet a summary of its work shows an aggregate exceeding the hundred-thousand-ton mark for merchant vessels as well as vessels of war. It will be noted by the following table that the gross tonnage of merchant vessels built and now building by this company is 111,735, while the displacement of vessels of war for the United States government, built and now under construction, is 105,930 tons. The duplications of names in vessels for the Morgan line is due to the fact that the first fleet built for that company (El Toro, El Sud, etc.), were sold to the government during the war with Spain and another fleet built immediately afterward.

LIST OF VESSELS BUILT BY THE NEWPORT NEWS SHIP BUILDING & DRY DOCK CO. AT NEWPORT NEWS, VA.

Type of vessel.	Name.	Gross tonnage of merchant vessels; displacement of war vessels.	Dimensions.	Built for.
Tug	Dorothy	130	90x19x10	New York & Northern Ry.
Tug	El Toro	130	90x19x10	Pacific Imp. Co.
Steamship	El Sud	4659	381x48x24	Morgan Steamship Co.
Steamship	El Norte	4659	381x48x24	Morgan Steamship Co.
Steamship	El Rio	4684	381x48x24	Morgan Steamship Co.
Steamship	El Cid	6888	381x48x22	Morgan Steamship Co.
Gunboat	Nashville	1371	220x38x11	United States government.
Gunboat	Wilmington	1392	251x40x9	United States government.
Gunboat	Helena	1392	251x40x9	United States government.
Pilot boat	J. H. Estell	243	118x23x13	Savannah Pilots Ass'n.
Tug	A. F. Dewey	134	92x19x9	Albert F. Dewey.
Steamer	Newport News	1535	260x46x14	N. & W. Steamboat Co.
Steamship	Grande Duchesse	5017	380x48x16	Plant Line.
Steamship	Creole	3801	352x44x15	Cromwell Line.
Tug	Sommers N. Smith.	211	105x21x14	Pensacola Pilots Ass'n.
Battleship	Kearsarge	11525	368x72x24	United States government.
Battleship	Kentucky	11525	368x72x24	United States government.
Steamer	Margaret	674	175x26x8	Plant Line.
Battleship	Illinois	11525	368x72x24	United States government.
Steamship	El Sud	4572	391x48x26	Morgan Steamship Co.
Steamship	El Norte	4605	392x48x26	Morgan Steamship Co.
Steamship	El Rio	4604	392x48x26	Morgan Steamship Co.
Steamship	El Cid	4608	391x48x26	Morgan Steamship Co.
Steamship	Comus	4828	392x48x28	Cromwell Steamship Co.
Steamship	Proteus	4836	391x48x30	Cromwell Steamship Co.
Tug	El Amigo	150	96x22x12	Morgan Steamship Co.
Steamship	El Valle	4605	380x48x26	Morgan Steamship Co.
Steamship	El Dia	4605	380x48x26	Morgan Steamship Co.
Steamship	El Siglo	4605	380x48x26	Morgan Steamship Co.
VESSELS IN COURSE OF CONSTRUCTION—(LAUNCHED.)				
Battleship	Missouri	12500	388x72x35	United States government.
Monitor	Arkansas	3200	252x50x15	United States government.
Steamship	Korea	11300	550x63x41	Pacific Mail Steamship Co.
Steamship	Siberia	11300	550x63x41	Pacific Mail Steamship Co.
Steamship	El Alba	4605	380x48x26	Morgan Steamship Co.
VESSELS IN COURSE OF CONSTRUCTION—(NOT LAUNCHED.)				
Cruiser	Maryland	13400	502x69x41	United States government.
Cruiser	West Virginia	13400	502x69x41	United States government.
Battleship	Virginia	15000	435x77x41	United States government.
Cruiser	Charleston	9700	424x66x40	United States government.
REBUILT IN 1901.				
Steamship	Main	10067	501x58x36	North German Lloyd Co.

A combination of circumstances has brought about lower freights in the closing days of lake navigation than prevailed during the month of November. Ships suddenly find it necessary to take to winter quarters. Grain and ore shippers moved earlier than they expected the number of cargoes that they had planned to ship after the middle of November and the coal shippers have been troubled as much as ever in getting the railways to forward coal to lake ports. Thus the season is not wound up with a struggle for ships at fancy rates, but this condition should have no special bearing upon another year's business. Vessel owners are as much encouraged as ever by the promise, still before them, that the greatest year in the history of the iron industry is to be succeeded by even a greater one. The pig iron market has shown further advances within the past few days, and in all speculation regarding the iron ore market for the new year prices somewhat higher than those of the year just closing are talked of.

SHIP BUILDING IN PHILADELPHIA AND VICINITY.

Philadelphia, Dec. 4.—With the Cuban mines again in full operation and from the nature of the contracts closed during the past few weeks it is safe to say that this port will again forge to the front as the most imporant market in the country for the imports of iron ore. Not only will the Daiquiri and Santiago mines be drawn on as a basis of supply, but those in Mediterranean ports as well. Charters made from Huelva, Bilboa, Garrucha and other points of shipment show that nearly 200,000 tons of ore have already been purchased and which will be landed on the Delaware river wharves. There are now over forty big tramp steamships loading or on their way to the various ports to load cargo for Philadelphia, distributed as follows: Wabana, 12; Daiquiri, 8; Santiago, 6; Bilboa, 15; Garrucha, 3; Vizagapatam, 4; Huelva, 5.

This encouraging outlook in the ore market is the source of great satisfaction to local ship builders. Edwin S. Cramp, superintending engineer of Cramp's ship yard, says that it is practically an assurance that the larger yards will not be crippled from lack of material. His views are also shared by President Matthias Seddinger of the Neafie & Levy company and by the New York Ship Building Co. The problem of armor plate is still, however, a serious consideration. The importation of ore will tend to secure unlimited quantities of manufactured steel shapes such as are used in vessels, but there is no certainty that the government will hurry the armor plate mills in filling their contracts or encourage them to increase their output. Armor plate is urgently needed for the battleship Maine, building at Cramp's yard, as only two small consignments have been received here. It is practically understood that if a serious delay is occasioned the builders by its non-delivery, they will file a heavy claim against the government, as in the instance of the battleship Alabama, in which the amount named was $234,000.

The Russian battleship Retvizan is ready to sail for home, having been finally accepted by that government. Capt. E. N. Stchensnovitch, her commander, as well as his entire staff, think she is superior to any battleship in the Russian navy and are still loud in their praise of her wonderful performance on the official speed run. Capt. Stchensnovitch, speaking of the disastrous effect of firing the battleship Alabama's turret guns directly across her decks, said that the Retvizan stood this stringent test extraordinarily well, only a partition or so being broken in the hold. He regrets that the 13-in. guns were not fired across decks at their extreme angle of elevation and depression. This was proposed while the vessel was undergoing her trials at sea but was abandoned owing to the objection of Cramp's engineer, J. Harry Mull, who feared damage to the bridge. The balance of the Retvizan's crew is expected from home in a few days. Her full complement will be over 700 men.

The feature in the petroleum trade during the week was the sailing of the British tank steamship Bloomfield, for Cette, France, with 2,080,864 gallons of crude petroleum. It was the largest cargo ever shipped from this port in a single vessel and in former years would have taken about eight vessels to have carried it. Shipments of petroleum from Jan. 1 to Nov. 30, inclusive, as compared with the corresponding period in 1900, show an increase in the exports of 70,591,187 gallons. The total shipment so far this year has been 360,080,692 gallons.

The Neafie & Levy company is preparing to launch the torpedo boat destroyer Barry. This craft will probably take the water in about two weeks.

The steamship La Grande Duchesse, which is being repaired at Roach's Ship Yard in Chester, at an expense of $50,000, for the Ocean Steamship Co. will have her name changed to City of Savannah.

PROGRESS OF WORK AT NEWPORT NEWS.

Newport News, Va., Dec. 3.—The protected cruiser Vineta, of the German Imperial navy, arrived in port recently from the Danish West Indies and will be placed in dry dock at once for examination and overhauling. It was stated at the ship yard that nothing would be known of the character of the work to be done on the Vineta until her bottom was exposed in dock. The cruiser has been stationed in the West Indies, and having some work to be done the German government decided to send her to this port, Newport News having the only private dry dock large enough to receive her. As she passed up the harbor to the ship yard salutes were exchanged with the United States battleship Alabama, which was filling her bunkers with coal off the Chesapeake & Ohio piers. The Vineta belongs to the second or protected class and her general dimensions follow: Length, 325 ft. 7 in.; beam, 57 ft. 10 in.; draught, 29 ft. 8 in. Her displacement is 5,900 tons. She is steel, sheathed, and has 4-in. hardened steel protection for decks and gun positions. She has triple screws, with a speed of 18 knots, and indicated horse power of 10,000. She carries two masts and three smokestacks. Her armament consists of two 8.2-in. rapid-fire guns; eight 6-in. rapid-fire guns; ten 3.4-in. guns; ten 1.4-in. guns and four guns of a milimeter caliber. She has three submerged torpedo tubes. Her normal coal supply is 500 tons. Her complement is 440, including officers. She was built at Danzig in 1897. During her stay it is probable that the officers of the ship will be tendered an elaborate reception by the city.

The battleship Missouri will be launched at the ship yard Dec. 28. Miss Helen Cockrell of Missouri, now of Washington, has been selected to christen the new defender.

The German steamship Scharzfelz, which arrived several days ago from Calcutta, bound for New York, landed here its crew of thirty-four East Indians, better known as lascars. The Scharzfelz sailed from Calcutta Sept. 18. The contracts with the coolies provide that they shall not be taken farther north than this latitude and the natives were put off here until the ship's return, bound back to Calcutta. The United States Shipping Co. handles a number of ships which are manned by coolie crews and it decided to establish a camp here for the convenience of the masters who are under orders to take their ships on to New York but can not take the lascars. The camp is a permanent institution.

The Pacific Mail leviathan Korea of 18,600 tons displacement will probably sail from the ship yard for San Francisco, via New York and the Suez canal, early in February. She will go on the route between San Francisco and Hong Kong. Her sister ship, the Siberia, will follow in about six months.

The remodeled cruiser San Francisco, which has been at the navy yard at Portsmouth for three years, will be placed in commission Jan. 2. Rear Admiral Bowles, chief constructor, is expected at the yard within the next few days to inspect the work on the cruiser, which will be ordered to the North Atlantic squadron.

The new Morgan Line steamship El Siglo was given her builder's trial outside of the Virginia Capes a week ago and she developed a speed of 18 knots, making her probably the fastest ship in the coastwise trade.

On Wednesday of last week seven large ships were handled in and out of the two dry docks at the Newport News works. Both docks are being used continually on a large amount of repair work. Officials of the yard will try to make a record on the Plant liner Olivette which is here receiving new boilers and a general overhauling. It was agreed when the bid for repairs was submitted that if conditions were favorable the work would be completed Dec. 15. The claim was made in some quarters that the work could not be done before Jan. 15. Rapid progress has been made and it is now more than probable that the ship will go to her owners by the 15th inst.

The German cruiser Vineta will be at the ship yard for about two weeks, as there is more work to be done on her than was expected. She is a triple-screw cruiser and makes a magnificent appearance as she rests in the basin.

The battleships Alabama and Massachusetts have sailed from Hampton Roads for Charleston to participate in some of the marine exercises at the exposition. The Kearsarge will join them there next week. While in the Chesapeake bay the ships had supplementary speed trials with good results.

The cruiser Topeka, which has been at Port Royal, S. C., for some time, is undergoing repairs at the navy yard. The cruiser San Francisco, which has been almost rebuilt, will be taken out of dry dock at the ship yard in a few days, and the United States collier Caesar, which has just returned from Manila, will be put in. The San Francisco will go into commission Jan. 1.

The Morgan line steamship El Siglo sailed from the ship yard Saturday morning for New York on her maiden voyage and will go at once on the route between New York and New Orleans. El Alba, the last of the Morgan ships, will leave the yard in a month or so.

SHIP YARD NOTES.

The monitor Florida was launched last Saturday from the Crescent Ship Yard, Elizabethport, N. J. The launch was in every way a success. All the armor and machinery and boilers were placed in the vessel before the launch. The vessel measures 3,000 tons and cost $100,000. She is 252 ft. long, 25 ft. beam and has a draught of 12.6 ft. She is fitted with triple-expansion engines of 2,400 H.P.

A five-masted wooden schooner, the James W. Paul, Jr., was launched from the ship yard of McKay & Dix, Bucksport, Me., last week. The vessel's dimensions are: Length, 250 ft.; breadth, 43 ft.; depth, 21.9 ft.; gross tonnage, 1,808; net tonnage, 1,653.75. She is the largest vessel ever built on the Penobscot river.

At Bath, Me., last week, the five-masted wooden schooner Mary F. Barrett was launched from the yard of G. G. Deering. She was ready for sea when launched. Her dimensions are: Length, 241.4 ft.; breadth, 43.4 ft.; depth, 24.7 ft.; gross tonnage, 1,833; net tonnage, 1,564.

Machinery is now being placed in the El Vivo, recently launched from the Johnson Iron Works, Algiers, La. The other vessel building, El Listo, will be launched in the early part of next month.

William McKie, East Boston, Mass., launched last week the four-masted schooner Kenwood for John S. Emory & Co. Her dimensions are: Length, 184.5 ft.; beam, 37.3 ft.; depth, 18.3 ft.

The Pittsburg & Morgantown Packet Co. of Pittsburg, Pa., has awarded to A. Axton & Son of Brownville, Pa., a contract for a side-wheel river steamboat to cost $50,000. She will be ready to enter the Pittsburg and Morgantown trade by June next.

A contract was awarded last week to the New England Ship Building Co., Bath, Me., for the construction of a 500-ton wooden schooner for Capt. M. D. McKown of Boothbay, Me. She will be 142 ft. long, 35 ft. wide, and will have a draught of 12½ ft.

It is reported that Kelley, Spear & Co., Bath, Me., have secured a contract to build a steamer for the Maine Central railroad. The vessel's dimensions will be: Length, 149.6 ft.; breadth, 28.8 ft.; depth, 9.5 ft.

The old ship yard of Samuel W. Tilton's Son, at Cooper's Point, Camden, has been purchased by John H. Mathis, Jr., who will at once make extensive improvements and extensions to the plant.

Mr. Arthur D. Story, Essex, Mass., has been given an order to build a new 68-ton wooden schooner for Capt. James Belleveau and others of Beverly, Mass. She is to be used in the cod fisheries.

The Enoch Moore & Sons Co., Wilmington, Del., is building a new wooden barge for Capt. Woodall of Georgetown, Md.

CANADIAN DREDGES.

The large hydraulic dredge J. Israel Tarte was tested in Toronto harbor on the 26th ult. This dredge was built for the improvement of the St. Lawrence route by the Polson Iron Works, Toronto, Ont., from designs by A. W. Robinson, consulting engineer to the Canadian government. She has a steel hull 160 ft. by 42 ft. by 12 ft. 6 in., and is designed to dredge clay from 50 ft. deep at the rate of 2,000 cu. yds. per hour and deposit it 2,000 ft. distant. It is capable of making a cut 300 ft. wide, being provided with a lateral feed and anchorage lines. Mr. Robinson has just completed a smaller dredge of 600 cu. yds. per hour capacity for British Columbia and which is now in service, and he is now at work on designs for a large dredge for the maritime provinces, which is intended to work in hard material in 56 ft. of water.

As indicating the increase in the use of oil as fuel in coasting vessels on the Pacific and on the Gulf of Mexico, it is noted from records in the office of the supervising inspector-general of steam vessels, Washington, that since Jan. 1, 1901, there have been issued permits to use petroleum as fuel on the Pacific coast to twenty-two steamers, and on the Gulf coast twenty such permits, the latter no doubt prompted by the recent discoveries of petroleum in Texas.

GRAIN, FLAX, FLOUR, ETC., AT DULUTH.

Duluth, Minn., Dec. 4.—Duluth grain shipments have been averaging from 500,000 to 750,000 bushels per day for the past forty days and the coming week will be larger than ever. Saturday last they were more than 1,150,000 bushels, nearly half flax. Duluth has become the great flax market of the United States. There has been traded here daily for the past sixty days more than 500,000 bushels, cash and futures. The sales of cash flax alone have often reached as high as 500,000 bushels a day. In the last two days of November the Duluth deliveries on cash flax for that month were at least 1,500,000 bushels, which is a very remarkable quantity for so late in a month; in fact it is a quantity that has never been approached in the history of the linseed market.

Receipts of grain at Duluth are very large, running about 3,000,000 bushels per week, and this rate is likely to be maintained for some time during the winter. Elevators will go into the winter with small stocks, but are expected to be well filled before spring. There is now 34,000,000 bushels elevator capacity at Duluth-Superior and the probabilities are that more will be added the coming season. The season is closing with all the accumulation of flour at the head of Lake Superior cleaned up. Three weeks ago it amounted to 40,000 tons, flour and feed. The car shortage and the lack of package freight ships has been a serious injury to the head-of-the-lake flour mills, several of which have been compelled to close down at the very time when of all others they should be running full. The average make of flour at Duluth-Superior for two months has been better than 40,000 barrels weekly and the indications are that this will be increased another season.

AERIAL BRIDGE ACROSS DULUTH HARBOR.

Duluth, Minn., Dec. 4.—Contractors Hugo & Tims have begun work on the substructure of the aerial bridge to be built across the entrance to Duluth harbor, at the ship canal. The same firm will erect the false work and may perhaps build the steel structure. On account of the lateness of the season it is not probable that anything more than the driving of piles for the foundations will be carried out this year. The concrete piers to cover these pile foundations will be put in early next spring and work on the superstructure will, it is expected, be carried on during the summer. If so the bridge is to be completed next August, otherwise it will not be ready till the following spring. The consent of the local engineer in charge is said to have been obtained to the continuance of operations all summer, providing a clear space 250 ft. wide be left for ships, and the matter is now before the department at Washington.

The American Bridge Co. will furnish steel through its Minneapolis works. For the foundation the piles will be sunk by water jet and seventy will be sunk under each of the two concrete piers in a space only 14 by 28 ft. The piling will be cut off about 10 ft. under mean water level and will be covered by 8 ft. of oak and pine timber, put in solid. One and a half feet below low water datum concrete piers covering the entire space and 9.5 ft. high will stand, on which the steel superstructure will be bolted.

AROUND THE GREAT LAKES.

Mr. E. L. Lenihan, well known on account of his conection for several years with insurance adjustments in the office of Chas. E. & W. F. Peck, Chicago, is now representing that firm in a branch office in the Williamson building, Cleveland. Adjustments will in future be conducted from the Cleveland office.

The weather bureau has just completed a steel signal tower at Big Point Sable, similar to the one built last summer at Ludington. The service in both cases will begin with the opening of navigation next spring. The tower at Point Sable stands in plain view of passing vessels which invariably run close to shore at this point. The weather bulletins will be communicated to the keeper of the Point Sable station by telephone from Ludington.

Officers of the International Seamen's Union of America, elected at the sixth annual convention in Buffalo, are: President, William Penje; vice-president, William Roberts; secretary and treasurer, W. H. Frazier. The president and secretary were reelected. A. Furuseth of San Francisco, Wm. Penje of Chicago and W. H. Frazier of Boston will represent the union at the convention of the American Federation of Labor to be held this week in Scranton, Pa.

In accordance with recommendation of the directors, the stockholders of the Cleveland & Buffalo Transit Co. at a meeting held in Cleveland Tuesday, added from surplus earnings $250,000 to capital, making it $1,000,000, and as shown by a statement published in these columns a couple of weeks ago the company still has a very creditable surplus, due to unusually large earnings during the past year. The new quarter of a million in stock is to be divided pro rata among the present stockholders.

Two new steamers which F. H. Clergue has announced his intention of putting on the run between Windsor and the Canadian Sault next season will, in connection with the Clergue steamers now running between Sault Ste. Marie and Michipocoten island, open up a vast country hitherto inaccessible to manufacturers, or practically so. The territory referred to is the land lying on the northern shore of Lake Superior eastward from Fort William and Port Arthur. This land is practically all virgin and is covered with timber of all kinds. Even now the trading posts of the Hudson Bay Co., established over 100 years ago, can be found doing business in the wilderness.

Herbert C. Sadler, professor of naval architecture at the University of Michigan (Ann Arbor), spent a couple of days last week with ship owners of Cleveland and with some of the officials of the American Ship Building Co. Prof. Sadler may undertake some consulting work in connection with his duties at the Michigan school, and proposes in any event to seek acquaintances that will keep him in touch with the ship building industry of the lakes. Before coming to this country he was assistant to Prof. Biles at Glasgow University and had unusual opportunity for acquiring experience as an expert in the various lines of consulting work in which he was engaged with Prof. Biles. He is a young man of apparent business energy, his manner not at all like that of most college professors, and it is more than probable that the knowledge of steel ship building which he brings from the home of the industry on the other side of the Atlantic will soon gain recognition for him in the lake region.

TOWING MACHINES ON THE PACIFIC.

A few of the steam towing machines that have been used to such great advantage during the past few years in handling large tows of the Atlantic seaboard and the great lakes have found their way to the Pacific coast, and as in all other cases where they have been introduced the steamboat men are most profuse in their praises of them. An instance of very severe service to which the machine has been subjected is found in the operations of the tug Samson, owned by the Hale & Kern Contract Co. of Portland, Ore. Letters from the United States engineer at Astoria, Ore., and from the engineer of the tug are decidedly interesting as showing what may be done with this machine under the most trying conditions to which a steam vessel is subjected in towing barges.

Hale & Kern of Portland, Ore., who own the Samson, have a contract with the government for building the Gray's harbor jetty. The Samson and the five barges which she tows were built by the contractors for the purpose of transporting rock and other material used in the construction of the jetty. The rock, procured on the Columbia river, is towed to Astoria from the quarry, 115 miles distant, by river boat. The Samson takes the barges from Astoria to Gray's harbor, crossing the Columbia river bar and Gray's harbor bar, going and coming. From the Columbia bar to Gray's harbor bar is about 35 miles of coast towing. The Samson is 126 ft. long, 26 ft. beam, and 14 ft. depth of hold. She has fore-and-aft compound engines, with cylinders of 20 and 40 in. diameter by 28 in. stroke, and Taylor water tube boilers that are allowed 225 lbs. steam pressure. The barges are 185 ft. long, 42 ft. beam and 16 ft. hold. They carry 1,500 tons of rock on 14 ft. draught. Writing to the American Ship Windlass Co. of Providence, R. I., manufacturers of the towing machine, Albert Rickards, United States engineer at Astoria, says:

"On May 19, while lying off the Columbia bar in the lighthouse tender Manzanita waiting for flood-tide, the Samson and her barge came out. The bar was rough and we could see the Samson leap out of the water, her whole hull in the air, while the barge was like a half-tide rock, the breakers going all over her with the force that is only known to those who battle with rough bars on this coast. Without this automatic machine such work would never be accomplished, as something must give when a heavy tug falls in such a sea and the barge butts into one at the same time. I think this work demonstrates more than anything else that I know of the worth of such a machine."

Chief Engineer James W. Hare of the Samson also writes the manufacturers at great length regarding the work of the tug in crossing the rough bars referred to. He is enthusiastic in praise of the towing machine. Bar work, he says, is the hardest service to which hawsers are subjected. "During the worst weather in winter," says Mr. Hare, "the barges were rigged as schooners, loaded with lumber and piles and towed to San Francisco, a distance of 600 miles. They carried 1,200,000 ft. of lumber on a draught of 16½ ft., so you see we have done all kinds of towing, both bar and deep-sea. But the strain on a hawser in the worst weather at sea is so insignificant when compared with the bar work that it is not necessary to say much of the deep-sea towing. I am satisfied that we have done at least 25 per cent. more work with the towing machine than we could possibly have done without it, to say nothing of the expense of parting hawsers and the danger of thus losing the barges. The machine has never failed to do all that was claimed for it. Two years ago I was in Seattle, Wash., and the Puget Sound Tow Boat Co. was building a new steel boat. I advised them to put in a towing machine but they were indifferent, as they were not fully informed regarding its worth. Last winter when in San Francisco I had a conversation with one of the principal owners of the tow boat company, and I so strongly endorsed the machine that he decided to put one in but could not convince the other owners. A short time ago one of their boats, the Tattoosh, came here to tow on the Columbia river bar. It was found that she could not do the work without a towing machine, so Capt. Libby, the manager of the company, came over from Seattle and after spending a day here concluded that he would send an order to you as soon as he reached home. Of course you know that the steamer Geo. R. Vosburg put in one of the machines and I firmly believe that the day is not far distant when a tow boat will not be considered complete without this device. You are at liberty to publish all or any portion of this letter."

MORE NEW SHIPS FOR THE GREAT LAKES.

Within the past week the American Ship Building Co. has booked orders for three steel steam vessels to cost about $900,000, thus increasing to $8,545,000 the value of vessels to be delivered during the coming year. The vessels for which orders have just been placed are a car ferry for the Pere Marquette Ry. Co., to cost about $400,000, and two steel freight steamers, to be duplicates of the Colonial and Yosemite, built at the Detroit works during the past year, and which are to cost about $250,000 each. One of these freighters is for A. E. Stewart, C. F. Bielman and others of Detroit, but the names of parties for whom the second steamer is to be built has not been given out. In general dimensions the new car ferry will be a duplicate of the steamer Pere Marquette, completed at the Cleveland works of the American company a short time ago, but she will have more power—enough to give a speed of 15 miles an hour. Dimensions of the freighters are: Length over all, 376 ft.; beam, 50 ft.; depth, 28 ft. They will have triple-expansion engines and Scotch boilers, the latter fitted with Howden hot draft apparatus.

The cigar-shaped lifeboat in which Capt. R. D. Mayo of Frankfort, Mich., and four companions left Chicago last Saturday afternoon in an attempt to cross Lake Michigan was overtaken and placed in tow during the night by the Barry line steamer Alice Stafford, which left Chicago early in the evening. When a point 22 miles off Grand Haven, Mich., was reached the tow line was cast off and the boat sailed the remainder of the distance to Grand Haven, arrived there at 10 o'clock Sunday morning. The purpose of making the trip was to demonstrate that the craft was an efficient life-saving device, and Capt. Mayo, its owner and inventor, asserts that its practicability is now definitely settled. The boat is about 15 ft. long and has an outside sheeting of steel. The interior contains two revolving floors, so that if the boat should begin turning in a heavy sea its occupants would not be inconvenienced to any great extent. The craft can only run before the wind, and if head breezes had been encountered during the trip it would have been blown back to the opposite shore.

NEW CLYDE LINERS AND WARSHIPS.

[Special correspondence to the Marine Review.]

Glasgow, Scotland.—No improvement has occurred in the demand for new ships, but no abatement can be discerned in the activity of the ship yards. There is plenty of work for some months to come, though the men's leaders are becoming anxious about next year. As activity abates after the New Year the wage question is bound to come to the front. At present ship builders, boiler makers, machinists (engineers, as we call them here), and, indeed, all the labor of the ship yard and engine shops, are receiving the highest wages they have ever earned. As the price of ships must come down before there can be a revival from the approaching depression, all the elements of cost will have to come down. It is not only that wages are high, but labor is made still more costly by waste of time. This is particularly the case with the riveters, who work in "squads" in such a manner that when one member of a "squad" chooses to laze, or go "on the bust," the whole of the rest are thrown idle. This is an old cause of complaint and the officials of the Boilermakers & Iron Ship Builders Society (trade union) have repeatedly lectured the men on the subject. They have now taken up the subject again on the complaint of employers about riveters leaving their work unfinished. But not only that; in several cases the riveters have refused to abide by the price list, drawn up three years ago by a joint committee of masters and men with a standing rates committee to arrange any differences that may occur with regard to items on the list. By refusing to abide by this list and to accept the decision of the rates committee when it is against them, the men are guilty of a gross breach of agreement. The executive council of the trade union, recognizing this, have put down the foot and have notified all their members in this district that they insist upon the agreement being honorably and honestly fulfilled and will compel malcontents to obey in the interests of the society itself. This is a proper course for trade union officials to take but the riveters are a queer lot to manage.

Meanwhile, the prospects of the freight market are not improved by the action of the miners, who are trying to prop up prices by restricting the output. This is merely serving to check the foreign demand, with a consequent smaller demand for tonnage. Many boats are now being laid up rather than accept the unremunerative freights offering, and the price of second-hand steamers has fallen enormously.

One of the most interesting vessels launched recently is the Dano-American liner Oscar II. This is a twin-screw boat built by Messrs. Alexander Stephen & Sons, Ltd. to the order of Det Forehede Dampskibs-Selskab of Copenhagen for passenger and cargo trade between Denmark and America. She is 520 ft. in length and of 10,500 tons register, has a depth of 59 ft. and her hull has been built in nine months. This vessel has seven complete or partial decks, most of them steel wood sheathed, the exposed weather-deck covering being of teak. The Copenhagen company has a fleet of 150 steamers, many of which are employed in the principal passenger and tourist line between Scandinavia and England. The Oscar II is expected to reduce the present steaming time from Copenhagen to New York by five days, and the accommodation is superior to anything hitherto provided. The boat has been constructed under the rules of the Bureau Veritas to the requirements of their highest class, special survey with P. R. mark. She has enormous strength forward (the shell plates being 1½ in. thick and the framing in proportion) in view of her route, on which she will often meet ice, especially at the European end. Her bulkheads are so arranged that she is practically unsinkable, and to insure greater strength and rigidity a steel middle line bulkhead is placed fore-and-aft at the center line. The emigrant and third-class passenger berths occupy the whole length of the upper 'tween decks, and accommodation is provided for over 700 persons. The third-class is divided into two, four, six and eight berth sleeping cabins, and the emigrant space into separate compartments for not more than twelve people each. Spacious dining and sitting rooms, finished in polished woods, are fitted up for each of these classes. The first and second-class passengers occupy the awning deck under the bridge, while special rooms have been built for superior first-class on top of bridge deck. Each class have dining saloons, smoke rooms, and deck promenades and lounges exclusively for their own use. Rooms are fitted up for 150 first-class and eighty second-class; and the saloons, occupying the full width of the vessel, can dine every person of each class at one time. Something like 1,200 persons can be accommodated each voyage. Electric light has been fitted in duplicate and each of the dynamos is capable of maintaining the full current required for all lights in the ship. Large holds and storerooms are insulated for the conveyance of game, butter, milk and vegetables. The refrigerating machinery for this purpose is capable of maintaining each of the seven compartments independently of one another, at any temperature ranging as low as 4° below zero, Celsius. The vessel has been designed to carry 8,000 tons deadweight, and her facilities for rapidly loading and discharging general cargo are up to date and very extensive. Ten steam winches and sixteen cargo derricks on derrick posts are fitted on the upper decks, while a special boom is provided for handling heavy pieces of machinery. There are two independent sets of powerful triple-expansion engines, and nine boilers supplying the necessary steam. The engine room is complete with all the latest and most improved description of pumps and other auxiliary machinery. Both hull and machinery have been entirely constructed at the Linthouse works of Messrs. Stephen & Sons.

The new Union-Castle liner Alnwick Castle for the London and South Africa service, built in the historic yard of Robert Napier & Sons, now owned by William Beardmore & Co., has just completed her official trials and been handed over. She is the first of two similar steamers ordered from Messrs. Beardmore for this line, specially designed for the company's extra cargo service to South Africa, with a carrying capacity of 7,000 tons on a moderate draught of water and a good sea speed. The general dimensions are: Length, between perpendiculars, 400 ft.; breadth, 50 ft.; depth to main deck, 29 ft. 8 in., molded; and gross tonnage 4,800. There is a complete teak shelter deck right-fore-and-aft and a cellular double bottom for water ballast. The vessel is built of steel to Lloyd's highest class under special survey. The most modern improvements have been supplied for the efficient working of the ship and the rapid handling of cargo, and comfortable accommodation has been provided for first-class passengers in a commodious deck house amidships, while a large number of third-class passengers and emigrants can be carried in the 'tween decks. The refrigerating space is on the lower deck aft, with suitable machinery for maintaining the various chambers at a low temperature, and the vessel has a very complete installation of electric lighting. The machinery consists of two sets of triple-expansion engines with cylinders 21½, 35 and 58 in. diameter by 4 ft. stroke, with four single-ended boilers, for a working pressure of 200 lbs. per square inch, fitted with the most recent appliances for efficiency and economy, including Howden's hot draft, bronze propeller blades, etc. On the trials a speed of 14 knots was easily attained.

A new Allan liner is always of interest on both sides of the Atlantic, and in the United States not less than in Canada. The latest addition to the fleet is the Ionian, built by Messrs. Workman, Clark & Co., Ltd., which has just completed a preliminary cruise and her speed trials. The dimensions of the Ionian are: Length, 470 ft.; breadth, 57 ft.; depth, molded, 40 ft.; and she will carry over 9,000 tons of cargo. The vessel has been built to the highest class of the British Corporation of Shipping, has the board of trade passenger certificate, is fitted to fulfil the requirements of the American passenger regulations, and has been specially designed for the North Atlantic trade. The bottom is constructed on the cellular double-bottom system for carrying water ballast, and ballast for trimming purposes is also carried in the fore and after peaks and in a deep tank placed aft of the engine room. The cargo space is divided into six holds by watertight bulkheads extending to the shelter deck, forming nine watertight compartments. The cargo can be worked simultaneously from six large hatchways, with twelve powerful steam winches and derricks. There are three complete steel decks, extending from stem to stern with a long bridge house amidships and a topgallant forecastle. The first-class passengers are placed in the bridge house, with additional state rooms on the upper deck below. On the deck above the bridge house is the entrance hall opening on to the promenade deck and enclosing a handsome staircase. Adjoining the entrance hall and entered from it is the music saloon. The second-class passengers are berthed on the upper deck aft of the engine room, and are comfortably fitted. Steerage passengers will be accommodated on the upper deck aft of the second-class space and forward of the machinery compartment, where berths are provided for about 500 passengers, with ample dining space. Refrigerating chambers for the carriage of perishable cargoes have been fitted up in the lower 'tween decks, and on the upper deck a cold store is provided for the reception of stores for passengers' consumption during the voyage. An installation of electric lighting is fitted throughout the vessel. All the living rooms throughout the ship are heated by steam, with the latest type of fittings The propelling machinery consists of tow sets of triple-expansion engines, with the most modern improvements in auxiliaries introduced. Steam is generated by four steel boilers working at a pressure of 190 lbs. per square inch, with natural draft. The Ionian takes her place in the Liverpool and Montreal service of the Allan line.

A type of vessel which may, perhaps, be new to some of your readers has just been launched by Messrs. Ramage & Ferguson, Ltd., Leith. This is a new steel steamer built and engined for the East Coast Salvage Co., Ltd., on the special design and under the supervision of the well-known salvor, Mr. T. N. Armit, manager of the company. She is arranged for general salvage and towing work. Her principal dimensions are: Length, 110 ft.; beam, 25 ft.; depth, 10 ft. She is of very light draught, a handsome model and is meant to be an excellent sea boat. Her engines are compound, 18-in. by 36-in. cylinders and 24-in. stroke, with large boiler power to give her an average speed of 10 knots. Her equipment comprises, amongst other specialties, extra strong towing gear, very large steam winch, horn at bow, very long and powerful derricks, steam digger, and other appliances for salving cargo; also electric light and special cocks and connections on main boiler for supplying steam to powerful salvage pumps. It is said of the boats of this salvage company that they can go anywhere and do anything.

A very severe storm delayed the launch (afterwards successfully completed) of the latest addition to the "County" class of cruisers—the first of two ordered by the government from the London & Glasgow Engineering & Ship Building Co., Ltd., Glasgow. The principal dimensions of the Monmouth are: Length between perpendiculars, 440 ft.; molded breadth, 66 ft.; load draught, 24 ft. 6 in.; displacement at load draught, 9,800 tons. The Monmouth is of the protected type of cruiser, her armor consisting of a belt between main and lower, or protective, deck, extending from the bow to the aft end of the machinery space. The main citadel armor extends the whole length of the engine and boiler space, and is 4⅛ in. thick; forward of the boiler space it is reduced to 3 in.; about the bow 2 in., and the bulkhead armor is of 3 in. The main deck, forming a crown to the armored portion of the vessel, is of two thicknesses, and is generally 1¼ in. thick. This and the lower deck, with the side and bulkhead armor, form a thorough protection for the machinery and other vital parts of the vessel. The vessel is divided into numerous watertight compartments, magazines and shell rooms are placed at the ends of the vessel well under the water line, and the coal bunkers, carried along each side, form an additional protection to the machinery space. The bunkers have a coal capacity of about 800 tons, but with reserve bunkers the quantity can be increased to 1,600 tons. The splendid machinery consists of two sets of triple-expansion four-crank engines, each set arranged in pairs, with the cranks of each pair directly opposite to each other and the cranks of the forward pair placed at right angles to those of the aft pair. The diameters of the cylinders and the order of their positions from forward are: Low pressure, 69 in.; high pressure, 37 in; intermediate pressure, 60 in.; low pressure, 69 in.; all having a stroke of 42 in. The combined power of the two sets of main engines will amount to 22,000 I.H.P. when running at 140 revolutions per minute. There are four surface condensers for the main engines, and two smaller condensers for the auxiliary engines. Each of the four main condensers is provided with sluice shut-off valves so that any part of one may be overhauled while the other is at work. The total condensing surface in the four is 23,000 sq. ft. The condensing water is supplied by four centrifugal pumps, each capable of serving two condensers. The air pumps for the main engines are worked by levers on the high pressure engines, one pump for each set of engines. There are six main and auxiliary feed-pumps, two hot-well pumps, four fire and bilge pumps, one latrine and one drain tank pump. The main circulating pumps, together with fire and bilge pumps, give a total pumping capacity of 5,200 tons of water per hour from the bilges. The crank, intermediate and propeller shafting is made by Messrs. John Brown & Co., Ltd. There are two sets of evaporators, each set consisting of two evaporators and one distiller, the combined output of which will amount to 200 tons per

twenty-four hours from evaporators and 70 tons per twenty-four hours from distillers. These are designed to work with the exhaust steam of the auxiliary system at a pressure of 25 lbs. per square inch or with boiler steam at the same pressure. The boilers are of the ordinary Belleville type with economizers. They are thirty-one in number, arranged in three boiler rooms, the forward set in each boiler room of the single-ended, and the after set of the double-ended type. As they have to work under assisted draft, there are four fans and two furnace air pumps in each boiler room. For ventilating purposes there are two fans in each engine room. There will be a complete installation of electric light, including six searchlights. The vessel with her armor and powerful armament is designed for a speed of 23 knots. The Monmouth's armament will consist of two twin 6-in. guns forward and aft in barbettes, four 6-in. guns in casemates on upper deck and six similar guns in casemates on main deck, eight 12-pounder 12-cwt. guns, two 12-pounder 8-cwt. boat and field guns, three 3-pounder quick-firing guns, and eight Maxim guns, in addition to which the vessel will be fitted with two submerged tubes, one on either side, for the discharge of 18-in. Whitehead torpedoes. The big guns are so arranged that a heavy fire can be maintained in any desired direction. The barbettes around the 6-in. twin guns are of 4-in. armor. The ammunition for these guns will be served through heavy armored trunks from the magazines and shell rooms below. The casemate fronts are of hard steel 4 in. thick, with rear plates 2 in. thick, and the conning tower, fitted above the forecastle deck, is of 10-in. armor, with a communicating tube 6 in. thick carried down to the protective deck and containing the connections to all the gear throughout the ship. The side bulkhead, casemate, and conning tower armor is made by Messrs. John Brown & Co., Ltd., and the barbettes by Messrs. Wm. Beardmore & Co., Glasgow.

In this connection it may be stated that invitations for tenders are about to be sent out by the admiralty for the battleships and armored cruisers to complete the naval program of the year. There is no likelihood this time of delay for want of the armor plates, because the production of armor has been greatly increased since the last admiralty orders were placed. Sheffield alone can now turn out nearly 30,000 tons per annum, besides the new plant of Beardmore & Co. at Glasgow and of Armstrong, Whitworth & Co. at Manchester.

RECONSTRUCTED CRUISER OLYMPIA.

The Olympia, formerly Admiral Dewey's flagship, is at present in dry dock at the Charlestown navy yard. Nearly all the changes in her have practically been completed. All of the main battery and part of the secondary battery guns are in place. The new stem and stern ornaments attract much attention, although the ship's hull is still a dirty white and the figures themselves have not been gilded. It is interesting to note that the new coaling device invented by Naval Constructor William J. Baxter, and which promises to solve a problem which has for years greatly bothered naval officers the world over, will be used for the first time aboard the flagship. This device has been given a test since it was fixed in place on the ship, and the result was most satisfactory. Mr. Baxter's appliance has been approved by the navy department. It is somewhat like a coal elevator in respect to the way it works. Had Schley's ships carried these coal handlers perhaps the famous controversy would never have occurred, because the admiral would have had no need to worry about being able to coal at sea. Two portable jointed I beams, extending over the side from the posts, fixed about amidships, serve as railways for trolley gear, which will receive bags of coal from a lighter and convey them to chutes leading to the bunkers, release them and travel back over the side for another load. It is expected that the device as now set up on the Olympia will prove as effective as any coal elevator on the water front, and it has the additional advantage that it may be taken apart and stowed away. The present system is to pass the bags from lighters, by hand, through the lower ports for the lower bunkers and to hoist bags on board with the davits for the upper bunkers. By Mr. Baxter's arrangement the lower bunkers may be filled by hand as usual, and his device will take care of the upper bunkers in remarkably short order, or, in the case of an emergency, will place coal on the upper deck to be stowed away conveniently by the crew. It is sure and economical, and by its use it is estimated a ship may be coaled in one-third the time now required.

INGENIOUS KEROSENE OIL MOTORS.

The British government, through officers in the army of India, is said to have had plans prepared in this country for wagons carrying kerosene oil engines. It is proposed in one instance to build a kind of automobile having as a driving power an electric motor, the current for which is supplied by a dynamo, which in turn is driven by an oil engine. The primary object of this carriage is to provide electric current to operate search lights. The electric motor is used to drive the carriage rather than have the oil engines do it direct, for the reason that a very flexible connection is thereby provided. This carriage is to be built for rough work in the field with a large army corps. Kerosene oil is used for the reason that it is not dangerous, like gasoline, and is almost universally obtainable. It has been so difficult to obtain fuel and water for steam engines used in the field with an army that the resort to the much simpler oil engine is a necessity. In addition to this automobile electric plant, it is proposed to construct oil traction engines for drawing supply wagons, and oil-driven machine shovels for making excavations. Oil for these engines will be supplied by tank wagons especially constructed for the purpose.

"These plans are additional proof," says an engineer who has given attention to the subject, "that for powers up to 100 H.P. the steam engine with its complications and frequent repairs will soon be a thing of the past." It is not possible to predict what changes the oil engine will work in this line of industrial development but it seems destined in many branches of industry to outrival the electric motor because of its independence of an outside source of power.

Mr. Francis G. Hall of the Naval Electric Co., 95 Liberty street, New York, has been engaged during two years past in developing for the Russian government the application of the oil engine to special purposes.

Mr. A. W. Robinson, member of the American Society of Civil Engineers, formerly of the Bucyrus Co., South Milwaukee, Wis., has been appointed consulting engineer to the Canadian government for river and harbor improvements and dredging plant.

OLD STYLE ARCHES IN WOODEN SHIPS.

Editor Marine Review: I take the liberty of writing to you to ask if any of the boats of the Rutland line, formerly the Vermont Central line, have now or ever did have high arches such as the steamers Empire State and Badger State have. There has been a good deal of discussion over the matter here and we would like to have it settled by you.

DOCK SUPERINTENDENT.

Ashtabula, O., Nov. 26, 1901.

Vessels of the Rutland line (formerly Vermont Central line) are the A. McVittie, F. H. Prince, Gov. Smith, H. R. James and Jas. R. Langdon, all wooden steamers of 2,040 tons each, built in 1889 and 1890; the W. A. Frost of 1,322 tons, built in 1883, and the Wm. A. Haskell and W. J. Averill of 1,550 tons each, built in 1884. All these vessels were built by the Detroit Dry Dock Co. None of them have arches of the kind in the Empire State and Badger State. The high arches in the Badger State and Empire State are what are known as the Bishop arches, named for the inventor. They were discarded about 1880 when the Union Dry Dock Co. of Buffalo built the steamers New York and Rochester. Both the New York and Rochester were fitted up with steel chords and diagonal iron straps, a method of stiffening that displaced the high arches used in the Empire State, Badger State and other vessels. It will be noted that all the Rutland line boats were built some years after the practice of steel chords and straps was adopted. It is well known, of course, that the steel chords extend under the main deck and under the between deck the full length all around the vessel, and that the straps are worked in diagonally between these chords. The steel chords are usually 18 in. wide and ¾ in. thick. With the straps they form a truss, that is a very strong support in a wooden ship.—Editor.

SHIP BUILDING IN NOVEMBER.

During the month of November ninety-two vessels of 21,099 gross tons were built in the United States and officially numbered by the bureau of navigation, treasury department. A summary of the vessels and their tonnage, prepared by the bureau of navigation, is as follows:

	WOOD.				STEEL				TOTAL.	
	SAIL.		STEAM.		SAIL.		STEAM.			
	No.	Gross tons.	No.	Gross tons	No.	Gross tons.	No.	Gross tons.	No.	Gross tons.
Atlantic and gulf	46	8,391	13	341	.....	.....	7	7,075	66	15,807
Pacific	5	3,511	6	703	.....	.....	.....	.....	11	4,214
Great lakes	.....	.....	1	99	.....	.....	.....	.....	1	99
Western rivers	.....	.....	14	979	.....	.....	.....	.....	14	979
Total	51	11,902	34	2,122	.....	.....	7	7,075	92	21,099

No steel sailing vessels were built in the United States during the month of November.

EARLY HISTORY OF PIG IRON.

The first blast furnace of which we have any reliable record appears to have been built in France, and it is said that one of the earliest makers of pig iron in England imported a workman from France to teach him the art. The first furnaces built in England were necessarily small and imperfect; nor do we find that smelting operations were carried on on anything like a large scale until the beginning of the second quarter of the present century. It was found necessary in 1581 to enact stringent laws to prevent the consumption of timber in any new ironworks within 22 miles of London; but even so recently as 1825 there were no more than 615,236 tons of iron produced in Great Britain, while, in 1840, the production had increased to 1,395,900 tons. In the interval between these two dates, Mr. J. B. Neilson of Glasgow took out his patent for the use of heated air instead of the cold blast, which had alone, until then, been used to support internal combustion in the blast furnace. In three years, by the use of this process, the quantity of coal necessary to smelt a ton of iron was reduced from 8.20 tons, coked, to 2.25 tons used in the raw state, and the production of iron was at the same time generally increased, owing chiefly to the use of a larger size of furnace.—Iron and Coal Trades Review.

A New York dispatch announces that Sir Christopher Furness, who sailed for England this week, carried away with him contracts for twelve freight steamers of 6,000 to 10,000 tons capacity. Besides these the dispatch announces that he has made arrangements with the Clergue interests at Sault Ste. Marie for the erection of a great ship building plant at that point—probably a matter of the distant future. Sir Christopher is credited with claiming to have discovered why the American manufacturer is crowding the British producer. He is quoted as saying that it is because economy in handling material has been brought to a science in this country. An American locomotive will haul twice the load that an English locomotive hauls with half the expense.

J. P. Morgan & Co., managers of the syndicate that underwrote the United States Steel Corporation, returned to the members of that syndicate last week the money that was called from them when the syndicate was formed. But $25,000,000, being 12½ per cent. of the $200,000,000 subscribed was called and returned. The return does not mean that the syndicate has been dissolved. The syndicate managers retain the profits which were made in its operations, and these profits, according to current Wall street reports, at present approximate 15 to 20 per cent. on the $200,000,000. The syndicate agreement was for fifteen months from March last. The managers, however, may dissolve the syndicate when they see fit.

Mr. C. B. Orcutt of the Newport News Co. has anounced that the company contemplates making extensive improvements in the ship yard in the near future. Among the improvements will be two new electric cranes.

BALANCING MARINE ENGINES.

FULL TEXT OF REAR ADMIRAL MELVILLE'S PAPER—HE BELIEVES THE MACALPINE SYSTEM TO BE THE BEST YET DEVISED—AWARDED A SPECIAL PRIZE.

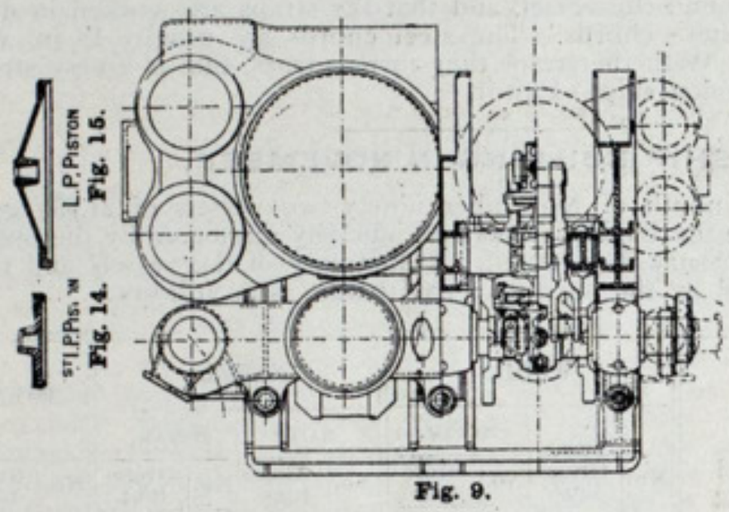
Rear Admiral George Wallace Melville and Naval Constructor D. W. Taylor were the authors of the prize papers upon the subject "The Theoretical and Practical Methods of Balancing Marine Engines," which were read at the recent meeting of the Society of Naval Architects and Marine Engineers in New York. The paper of Naval Constructor Taylor, to which was awarded the prize, was reproduced in a condensed form in the Review of Nov. 21. A special prize was given to Rear Admiral Melville's paper, which is reprinted herewith. Rear Admiral Melville's paper is devoted to the MacAlpine system, which he believes to be the best solution of the problem of engine balancing to prevent hull vibration that has thus far appeared. Mr. John H. MacAlpine, the author of the system, had been hitherto associated in his work with Admiral Melville. The paper follows:

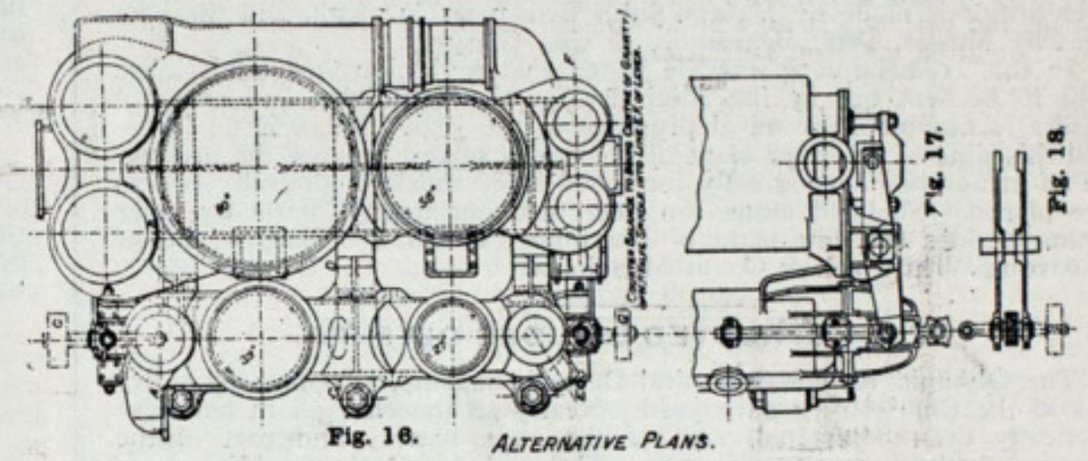
The balancing of engines has been familiar to the engineering profession for a great many years, particularly in locomotive engines and very high speed engines on shore. Within the past fifteen years, the subject has attracted much more attention among marine engineers on account of the effect of lack of balance in the engine in causing disagreeable vibrations in the hull. The matter has been brought before various engineering societies by some of the most accomplished leaders in the profession, and several systems have been actually applied in practice, while still others have been advanced with strong arguments to show their capacity to solve the problem of engine balancing and thereby that of hull vibration. The system which has thus far been applied to the greatest extent in practice is the Yarrow-Schlick-Tweedy system of four cylinders with unequal crank angles and other arrangements for preventing vibration. While this system has been partly successful in accomplishing its aim, competent observers on the ships to which it is fitted have found that it is not a complete solution of the problem, and, indeed, in some cases the vibration has been said to be almost as bad as with unbalanced engines. Mr. John H. MacAlpine, who has published a number of articles on this subject, is a personal friend of the writer, and has favored him with very complete information with respect to a system devised by Mr. MacAlpine, and which is a complete solution of the problem of balancing a marine engine. The members of this society are, of course, well aware that our navy has not adopted the Y. S. T. system of engine balancing, and as the writer is in a position to know the reasons which have actuated the engineer-in-chief of the navy in his decision, he believes it will be of interest to present to the society a discusson of the various methods which have been proposed or actually tried for balancing marine engines, including the Y. S. T. system, giving their merits and demerits, and going at considerable length into the MacAlpine system of balancing, which the writer believes to be the best solution of the problem thus far presented. Obviously, in a discussion which aims to give a history of the subject, prominence will be given not only to systems which are correct, but to those which are only partially so.

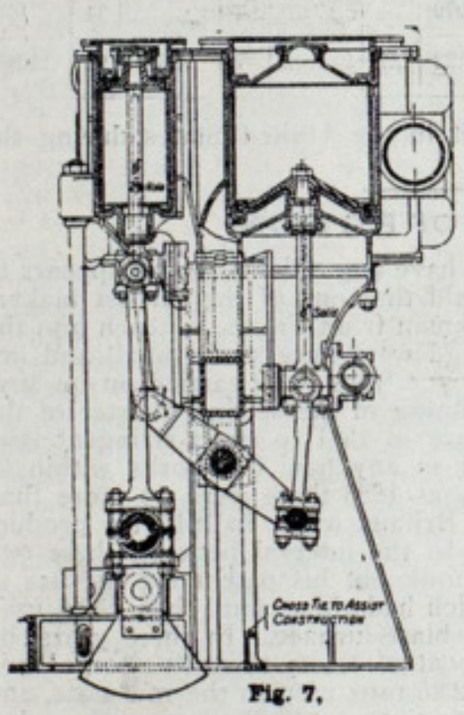
Unbalanced engines do not at all times vibrate a ship, but only at particular speeds of revolution. This is a well-known fact which can be readily observed by everyone who has been on board ship to any great extent—one which has been clearly brought out by many writers on our present subject. For instance, Mr. Yarrow says, in his paper read in 1892 before the Institute of Naval Architects: "Some years since, we had a boat in which severe vibration occurred at 200, 400, 600, and 800 revolutions per minute, but there was none at the intermediate speeds of 300, 500, and 700." Thus there are the proverbial two sides to this question. The engine must supply impulses to the ship at or near the rate at which the ship itself would naturally vibrate. In other words, there must be synchronism between the speed of revolution of the engine and the free vibration of the ship. We may recall the old illustration of soldiers marching over a suspension bridge, where, if the step corresponds with the rate of vertical swing of the elastic structure, there is danger of breaking down the bridge by producing a large vibration. If the rate of march is increased or diminished, the vibration of the bridge will diminish, but the usual practice is to make the soldiers "break step," so as to avoid any chance of the dangerous timing of the impulses. If, in the ship, we could always be sure of avoiding these troublesome speeds of revolution, there would be little need for accurately balancing engines. But it would be far too serious a restriction on the use of the engines, and it is impossible to predict with any sufficient degree of accuracy what the period of vibration of the ship will be. Besides, Mr. Yarrow's experiments bring out what is otherwise very well known, that the ship is capable of responding to very different speeds of impulse—or, in other words, it may vibrate in many different ways, each having a period peculiar to itself.

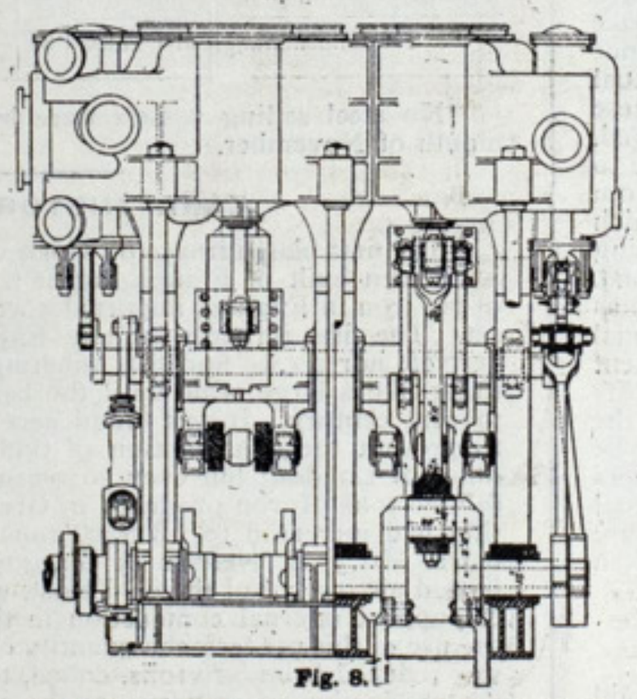
It is now fully recognized that a reciprocating engine of the usual kind does not supply merely one set of impulses at the same rate as it revolves, but a number of different sets of sensible magnitude and various periods. This makes the problem of preventing vibration by the adoption of a particular speed of engine a greatly complicated one. Thus the whole problem is complicated mathematically, whether we consider the effect produced on the ship or the forces we have to deal with in the engines. If we can produce an engine which, when placed in the comparatively delicate elastic structure of the ship, will have all its inertia forces balanced, so that they do not strain the ship, or if only those are transmitted to the hull which will not nearly synchronize in period with vibrations of a kind they could excite, consideration of the effect on the ship practically ceases to be part of the problem. To produce such a balanced engine we must adequately meet the comparatively complex dynamical conditions in the engine, and the solution must be not merely a theoretical one, but it must result in an engine which will not fall behind our best marine engines of today in steam consumption, and must be equal to them in first cost, upkeep, and practicability generally.

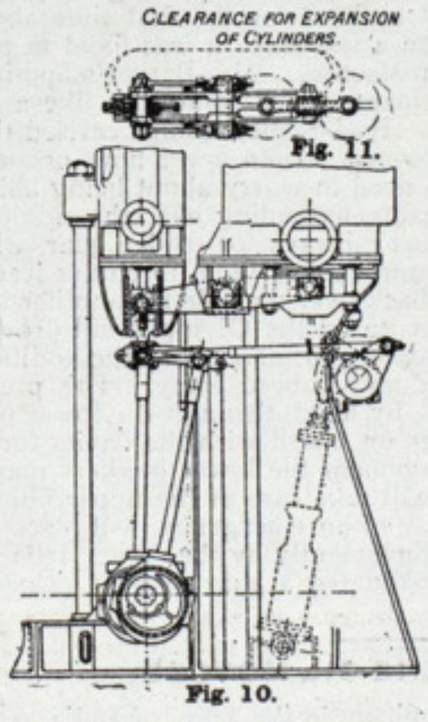
If it was merely a diagram or design on paper that was wanted, it would be easy to produce a great variety of "theoretically" balanced engines. If, for instance, we were allowed to "suppose" an infinite connecting rod, or to "suppose" that a slotted crosshead would work as well as a connecting rod, all we require is to make an engine with three cranks in one plane, the center one standing up when the outer ones were pointing down. Counterbalance the cranks and properly adjust the reciprocating weights, and the balance is perfect. The engine would not start from its dead points, but that would be found to be only one of its minor defects. Such sentences are, no doubt, trivial. Unfortunately, they are not more so than many of the proposals that have seriously been put forward in this connection, all of which we may dismiss as impracticable without any further notice. We are not at liberty to make suppositions.











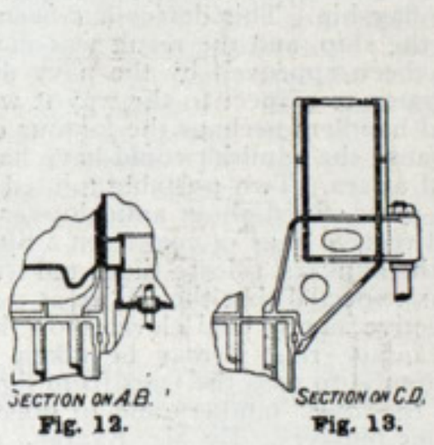


Plate 1. Cylinders 27, 39, 56 and 80 in. by 48 in. stroke; boiler pressure, 200 lbs.

We have our limits of weight and space, the dynamical problem is definite, and the inexorable laws of nature will be our judge whether we have clearly comprehended the conditions or sufficiently submitted to them in carrying our theory into practice. It is a theoretical and practical problem, and both sides must be fully attended to. Or, in the quotation very familiar in this country, "It is a condition and not a theory which confronts us."

Much that deserves notice has proceeded on the assumption that the connecting rod might be treated as of infinite length, but, unfortunately, this leads to the omission of forces of considerable magnitude. If of infinite length, the inertia of the piston and other reciprocating weights would be of the same intensity at each end of the stroke, say at top and bottom stroke, in a vertical marine engine. Designate this force by F. Now let us see the effect of a connecting rod of finite length. It has long been known that if r is the crank radius and l the length of the connecting rod, the actual forces are:

$$\text{At top stroke, } F\left(1+\frac{r}{l}\right) = F \times \frac{5}{4} \text{ where } l = 4r.$$

$$\text{At bottom stroke, } F\left(1-\frac{r}{l}\right) = F \times \frac{3}{4} \text{ where } l = 4r.$$

So that, for the length of connecting rod very commonly employed, the forces at top and bottom stroke, instead of being equal, as supposed, actually bear the ratio of 5 to 3; the force at top is nearly double the other. Any system which does not take account of this difference cannot be considered perfect. It may be looked on as a first approximation, but an approximation far from satisfactory. We have this defect in the Wells' engine, a type of engine which has been patented by many inventors under the impression it was balanced. In it, two cylinders are arranged, one above the other, in line. The upper and lower pistons are actuated by exactly opposite cranks, and the intention is that the inertia of the lower piston and attached moving parts at, say, bottom stroke, will balance the inertia from the upper piston and its attached parts at top stroke. The intention is far from being fulfilled, as we have just seen, and it was, doubtless, for this reason that Admiral Melville, a number of years ago, declined to approve it. The engine has some good points, but I think that defects are what has hindered its progress. When the Y. S. T. system was proposed, it was not suggested that it in any degree took account of the effect of the finite length of the connecting rod. That it does not do so will be shown fully in the sequel. This is the reason for the non-adoption of this system by our navy, and I believe that actual experience has justified this course.

I will now develop the theory of the subject so far as to explain sufficiently all of value that has been done, and will give the reasons for my belief that the MacAlpine system of balancing is the best. The fundamental problem may be said to be the counterbalancing of a simple revolving piece, and with this I will commence. Suppose a revolving shaft to have a projecting arm or crank. The centrifugal force of this part will tend to deflect the shaft in the direction of the arm. This centrifugal force is readily calculated. If M_1 is the mass of the arm in pounds, and R_1 the radius of its center of gravity from the shaft center, in feet; also, if w is the angular velocity of the shaft in radians per second, and g the intensity of gravity, the whole centrifugal force, as is well known, is

$$F_1 = \frac{M_1 w^2 R_1}{g}, \tag{1}$$

F_1 being also in pounds.

Now, to counteract this centrifugal force, all we need do is to place a counterbalancing arm on the opposite side of the shaft, the line through the centers of gravity of the original and counterbalancing arms being at right angles to the axis of the shaft. If, then, M_2 and R_2 are the mass and radius of the center of gravity for the counterbalance, we have the centrifugal force for it

$$F_2 = \frac{M_2 w^2 R_2}{g}, \tag{2}$$

and to get an exact balance we make

$$M_2 R_2 = M_1 R_1, \tag{3}$$

We can thus exactly balance the cranks of any engine and the parts revolving with them, such as the lower part of the connecting rod. This would leave the vertical inertia forces from the upper part of the connecting rod and the parts above it entirely unbalanced, and these would cause vertical vibrations of the ship. Now, it is the vertical vibrations that are principally troublesome. Even when the cranks are uncounterbalanced, the horizontal forces rarely have produced troublesome horizontal vibrations, the principal reason being that the ship is much stiffer when bent in a horiozntal than in a vertical plane. Probably, also, the waves produced carry away more readily the energy of horizontal than of vertical vibrations. The vertical downward force from the counterbalance is

$$F_2 \cos \phi = \frac{M_2 w^2 R_2}{g} \cos \phi, \tag{4}$$

where ϕ is the angle by which the crank has passed top center. This is obtained at once by resolving vertically the whole radial force from the counterbalance. It is a force due to a simple harmonic motion of the same period as the engine revolution. If the connecting rod were of infinite length, the piston and other reciprocating parts would also have a simple harmonic motion of this period, and the intensity of the upward force from them would be

$$F = \frac{M w^2 R}{g} \cos \phi, \tag{5}$$

where M is their total reciprocating mass and R the crank radius.

As the forces in equations (4) and (5) follow the same law of variation, the whole vertical inertia force could be counterbalanced if the connecting rod could be made of infinite length. Now, if we examine the differences of the actual motion of the piston, and that it would have were the connecting rod infinite, we would find that these differences followed quite a different law of variation from that of the above equations. Hence the simple harmonic motion, got by supposing an infinite connecting rod, is only an element of the actual motion with the connecting rod finite, and it is the only part of it which can be balanced by a counterbalance. Thus we may make the counterbalance such that

$$M_2 R_2 = M_1 R_1 + MR. \tag{6}$$

We will then have that part of the whole vertical force, which has a simple harmonic motion of the same period as the engine, counterbalanced; but the horizontal forces will be overbalanced. As MR is not usually greatly different from $M_1 R_1$, the correct horizontal balance will have been almost doubled, or, otherwise stated, the unbalanced horizontal forces will now be about as great as when no counterbalances were fitted, but in the opposite direction. Since, as noted above, the horizontal unbalanced forces do not usually cause trouble, there is no very great objection from this point of view to a counterbalance as large as given by equation (6).

Practice varies between the limits given by equations (3) and (6). One practical objection to the larger value, besides the very considerable addition to the weight of the engine, is that, if steaming at reduced initial pressure, the crank shaft may never be lifted off the lower brass of the main journals, thus causing imperfect lubrication, heating, and rapid wear. Instead of counterbalances on the cranks, revolving arms, placed usually forward and aft of the engine, have been fitted. In most cases, the total weight of counterbalance will be considerably smaller than if each crank is separately dealt with. Their exact position being determined to suit the design, their mass, radius, and the angles at which they stand to the cranks can readily be determined. This can be done either entirely by calculation or by a semi-graphical process. It will be sufficient to indicate the former method here. Let the cranks be designated by the numbers 1, 2, 3, 4, etc., in order from the forward end, m_1, m_2, m_3, m_4, etc., are the corresponding moving masses. That is, the mass of the crank is to be reduced to crank radius, so that instead of M_1 of equation (1) we take

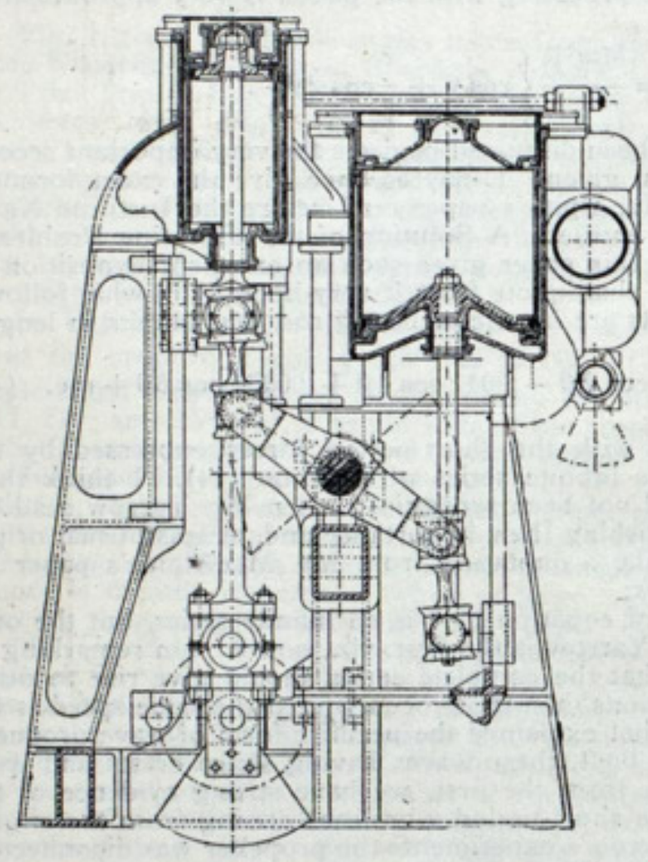


Fig. 19

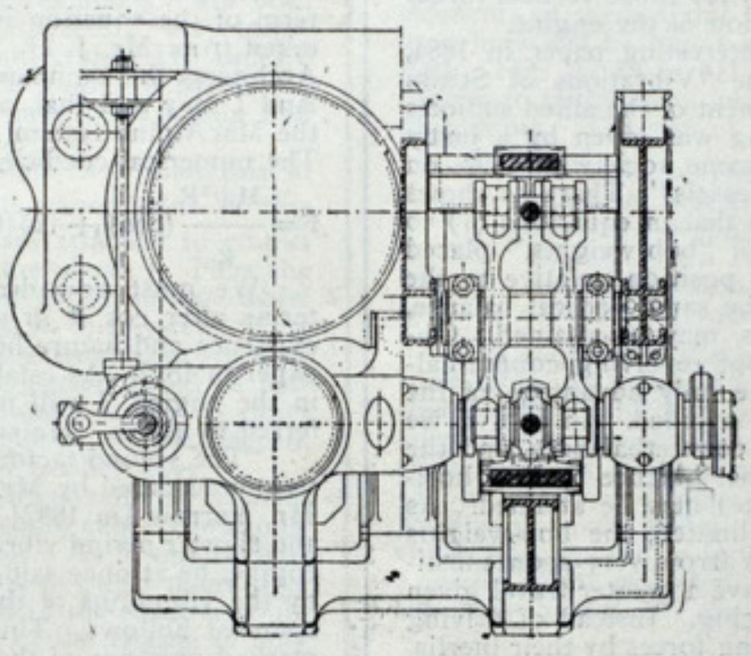


Fig. 20

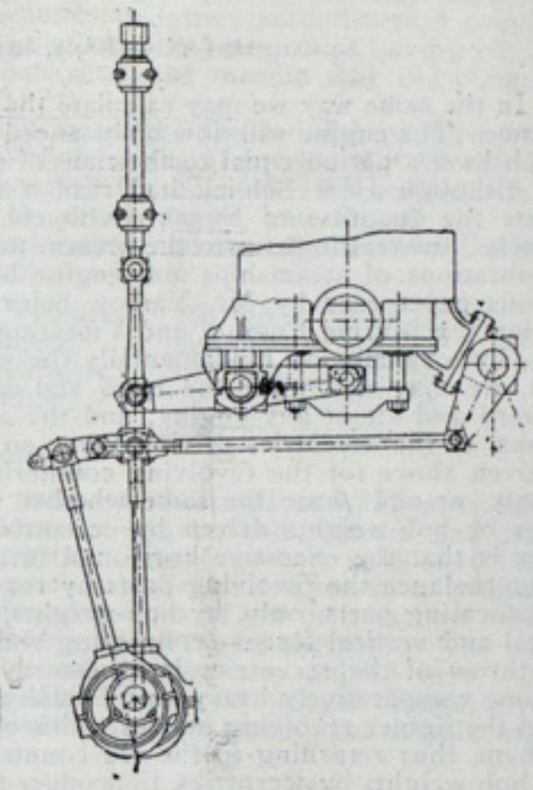


Fig. 21.

Plate 2. Cylinders 27, 39, 56 and 80 in. by 48 in. stroke; boiler pressure, 200 lbs.

$\frac{M_1R_1}{R}$. To this is to be added the whole of the connecting rod and parts moving with the crosshead to make up m. a_2, a_3, a_4, etc., are the angles by which the cranks 2, 3, and 4, etc., respectively lead crank 1, and ϕ is now the angle by which crank 1 has passed top center.

The positions of the counterbalances, chosen to suit the design, will be known, as will also the values of the m's and a's and the fore and aft positions of the cranks. We may then express the moment of all the forces (including valve gears or any other attached parts, which will be reduced to crank radius and treated exactly as the cranks) about the forward counterbalance. For a balance, this moment must always be zero. Take d_1, d_2, d_3, etc., as the distance the respective crank centers are aft of the forward counterbalance; and let n, β, e, and r be the mass, angular advance, distance and radius of center of gravity of the aft counterbalance. The moment then is

$$\frac{w^2}{g}[R\{m_1d_1\cos\phi + m_2d_2\cos(\phi+a_2) + m_3d_4\cos(\phi+a_3) + \text{etc.}\} + ner\cos(\phi+\beta)] = 0. \quad (7)$$

For the balance required equation (7) must always be zero; and, as is well known, this will hold if it holds for two values of ϕ not differing by two right angles. Take $\phi = 0$ and $\phi = \frac{\pi}{2}$. Then

$$\phi = 0 \,.\, nr\cos\beta = -\frac{R}{e}(m_1d_1 + m_2d_2\cos a_2 + m_3d_3\cos a_3 + \text{etc.}) = A, \quad (8)$$

$$\phi = \frac{\pi}{2} \,.\, nr\sin\beta = -\frac{R}{e}(+ m_2d_2\sin a_2 + m_3d_3\sin a_3 + \text{etc.}) = B. \quad (9)$$

As all the quantities entering into A and B are known, we can at once calculate nr and β thus,

$$nr = (A^2 + B^2)^{1/2},\ \tan\beta = \frac{B}{A}. \quad (10)$$

In the same way we may calculate the values for the forward counterbalance. The engine will now be balanced exactly for those vertical forces which have a period equal to the time of revolution of the engine.

Although Herr Schlick had read a most interesting paper in 1884, before the Institute of Naval Architects, on the "Vibrations of Steam Vessels," the real impetus to the present development of the allied subjects of vibrations of steamships and engine balancing was given by a justly famous paper read by Mr. Yarrow before the same society in 1892, on "Balancing Marine Engines and Vibrations of Vessels." There he shows how, by a calculation fundamentally the same as that in equations (7) to (10), we may determine the mass and stroke of "bob-weights," placed forward and aft of any engine; and the angular position, relative to the cranks, of the eccentrics driving them, so that the same vertical balance, as given above for the revolving counterbalances, may be attained. Obviously, nr and β are the same whether we adopt revolving counterbalances or bob-weights driven by eccentrics. The only advantage of the latter is that the excessive horizontal forces are avoided. In fact, if we counterbalance the revolving parts by revolving counterbalances, and the reciprocating parts, only, by bob-weights, an exact balance both of horizontal and vertical forces (connecting rod infinite) may be attained. As the throw of the eccentrics is necessarily very limited, the bob-weights become comparatively heavy; and I believe Mr. Yarrow very soon substituted the lighter revolving masses which could have a greater travel given to them, thus returning to the old counterbalancing. Instead of driving idle bob-weights by eccentrics, to produce balancing forces by their inertia, we may evidently transform the eccentric into a crank and make the bob-weight into the piston, etc., working in a cylinder. Its first function will not be interfered with by this change. When this is realized in a four-crank engine, we have the Y. S. T. system. I will only give the equations referring to this system. Using the same notation as before, we have for the total upward force

$$\frac{w^2R}{g}\{m_1\cos\phi + m_2\cos(\phi+a_2) + m_3\cos(\phi+a_3) + m_4\cos(\phi+a_4)\} \quad (11)$$

Similar terms being added to include the mass of the valve gears, etc., reduced to crank radius. Taking the moments about the forward crank and measuring d_2, d_3, d_4 from the center of this crank, we get the equation for moments,

$$\frac{w^2R}{g}\{d_2m_2\cos(\phi+a_2) + d_3m_3\cos(\phi+a_3) + d_4m_4\cos(\phi+a_4)\}. \quad (12)$$

To obtain a balance we must equate these to zero at two positions of the revolution, say at $\phi = 0$ and $\phi = \frac{\pi}{2}$. We then get the four equations.

$$\left.\begin{aligned}
&\text{From (11), } \phi = 0 \,.\, m_1 + m_2\cos a_2 + m_3\cos a_3 + m_4\cos a_4 = 0\\
&\text{From (11), } \phi = \tfrac{\pi}{2} \,.\quad m_2\sin a_2 + m_3\sin a_3 + m_4\sin a_4 = 0\\
&\text{From (12), } \phi = 0 \,.\, d_2m_2\cos a_2 + d_3m_3\cos a_3 + d_4m_4\cos a_4 = 0\\
&\text{From (12), } \phi = \tfrac{\pi}{2} \,.\, d_2m_2\sin a_2 + d_3m_3\sin a_3 + d_4m_4\sin a_4 = 0
\end{aligned}\right\} \quad (13)$$

We may choose three of the quantities, say m_1, m_4, and a_4, and by solving the equations find corresponding values of m_2, m_3, a_2, a_3; d_3 and d_4 will be practically determined by the design. I merely give equations (13) to show clearly the scope of the Y. S. T. system and its limitations; and also for a subsequent remark on the effect of short period forces. I do not give methods of solution, as I am not advocating the scheme. Those wishing to follow the matter further may consult the article on "The Causes of Vibration of Screw Steamers," by Assistant Naval Constructor D. W. Taylor, U. S. N., in the Journal of the American Society of Naval Engineers, Vol. III, p. 20. Constructor Taylor was the first to propose a four-crank engine with unequal crank angles in order that the tendency to vibration might be "practically annulled." Also, see Herr Schlick's paper, "Further Investigations of the Vibrations of Steamers," Institute Naval Architects, 1894. Admirable methods of semi-graphical solution, which can be applied to this system, including valve gears, are given by Prof. Dalby in a paper, "The Balancing of Engines, with Special Reference to Marine Work," Institute Naval Architects, 1899, and in one by Mr. J. Macfarlane Gray. "The Geometry of Engine Balancing," read before the same society this spring (1901).

If the cranks are so far counterbalanced as to make the masses of the revolving parts reduced to the crank radius—that is, the webs, pin, and part of the connecting rod—proportional to m_1, m_2, m_3, m_4, evidently these revolving parts are balanced among themselves at all parts of the revolution. Thus the horizontal as well as the long period vertical forces are balanced. I believe this horizontal balance is not usually carried out in practice, though this is the only advantage that can possibly be claimed by the Y. S. T. system over the older counterbalancing by revolving weights at the end of the engine. As already shown, this latter leaves unbalanced horizontal forces, but such as rarely give trouble. The revolving counterbalances have the advantage of great simplicity, and the avoidance, early in the design, of the troublesome determination of crank angles and adjustment of moving masses, with the attendant difficulty of making different parts of the crank shaft replaceable by one spare section. Also, we are not tied down to a four-crank engine. That the Y. S. T. system does not give a perfect balance, and that the difficulties above mentioned are not imaginary, are brought out more strongly by the fact that the system has only been used to a limited extent, and where it was important to claim that at least an effort had been made to solve the problem. We will incidentally examine it a little further in treating the effects of the forces which pass through two complete cycles in one revolution of the engine. These are the forces which principally account for the inertia at top stroke being so much greater than at bottom stroke. These short-period forces are not produced at all by revolving counterbalances, which is much in their favor. It has long been known that the inertia from the parts reciprocating with the piston is very approximately given by

$$F = \frac{Mw^2R}{g}\left\{\cos\phi + \frac{r}{l}\cos 2\phi\right\}.$$

All that has thus far been discussed neglects the very important second term of the equation just given. I may at once give the exact formula, taken from Mr. J. H. MacAlpine's paper read before the Institute Naval Architects this summer, entitled "A Solution of the Vibration Problem." And I may add that, as this paper gives such an excellent exposition of the MacAlpine system, I shall quote from it very liberally in what follows. The numerical coefficients are for a connecting rod four cranks in length.

$$F = \frac{Mw^2R}{g}(\cos\phi + .2540\cos 2\phi - .0041\cos 4\phi + .00007\cos 6\phi + \text{etc.} \quad (14)$$

We must now deal with the short-period forces expressed by the terms after cos ϕ in the infinite series of equation (14). I think their existence and nature had not been recognized when Mr. Yarrow read his paper in 1892. As establishing their importance and, at least, usual origin in the engine, I will make a quotation from Mr. MacAlpine's paper referred to above. He says:

"The second factor of equation (1)* is an infinite series, but the only term considered by Mr. Yarrow is the first, viz., cos ϕ. On remarking to Mr. Yarrow [in 1892] that the complete series should give rise to other and shorter period vibrations than those occurring at the same speed as the engine, he at once said that explained the peculiar form of wave produced by the vibrations of the boat, these waves having sharp crests and well-rounded hollows. Thus, from the first, we have strong evidence of the marked presence of those short-period vibrations arising from the engine—for in many of Mr. Yarrow's experiments the propeller was diconnected. In the same year, 1892, Mr. H. C. Flood and I made observations on the Circassia, and found not only vibrations of the same period as that of the revolution of the engine, but also, very prominently, those of one-half and one-fourth of that period. These we called the first, second and fourth period vibrations. There were also marked indications of vibrations of the sixth and eighth period, but no trace of any odd period. This is precisely what we would expect from equation (1), which contains, besides cos ϕ, only the cosines of even multiples of ϕ. In several other respects, detailed in our paper, the observations confirmed what theory would lead us to expect; and I think they leave no doubt that these vibrations originate in the engine. Scarcely has there been a vibration diagram published which has not borne the clearest evidence of those of short period; and no one who has followed the development of this whole subject could fail to be struck by the growing recognition of their importance. Indeed, in two cases which came under my own observation, and in one which was observed by a friend, the second period vibration was much more prominent than that of the first period. I maintain that the short-period forces must be balanced in any completely satisfactory solution of the vibration problem, and this cannot be done with the ordinary type of direct-connected marine engine."

Perhaps no stronger proof could be given of the importance of short-period vibrations than the fact that Herr Schlick, who has made so many excellent observations of vibrations of ships, read an elaborate paper in 1900 before the Institute of Naval Architects, to prove that the Y. S. T. engine could be practically balanced for second period. With this claim, however, I cannot agree, and I believe it has not been substantiated. The reasons for this I will give shortly. The importance of these high-period vibrations being now thoroughly recognized, I will give a simple method of judging quickly the degree of balance or unbalance an engine has with regard to any particular period, and use it in two cases. This method has been used both by Mr. MacAlpine and by Prof. Dalby.

The second period forces and couples are given by expressions similar to (11) and (12). That for the forces is

$$\frac{.2540\,w^2R}{g}\{m'_1\cos 2\phi + m'_2\cos 2(\phi+a_2) + m'_3\cos 2(\phi+a_3) + m'_4\cos 2(\phi+a_4)\}. \quad (15)$$

*Equation (14) of the present paper.

I have replaced m by m', as only the parts moving with the crosshead and part of the connecting rod give rise to higher period forces. Beyond this difference and the introduction of the factor .2540, this expression only differs from (11) by all angles being doubled. If, then, starting from any particular engine A we keep the forward crank at top center and double all the angles by which the other cranks and eccentrics stand to the forward crank, we get a new engine B. Neglecting differences of m and m' in expressions (11) and (15), engine B will have the same degree of balance or unbalance for first period forces and couples as engine A has for second period. Similarly, by quadrupling the crank angles we get an arrangement by which the balance or unbalance of fourth period may be easily judged. And so on for all periods.

First, let us apply this to the crank angles of the Deutschland, which is balanced on the Y. S. T. plan.

Deutschland's crank angles.

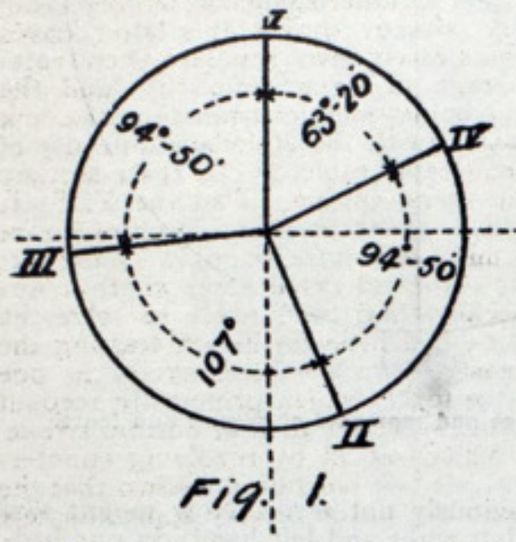


Fig. 1.

Deutschland's crank angles doubled.

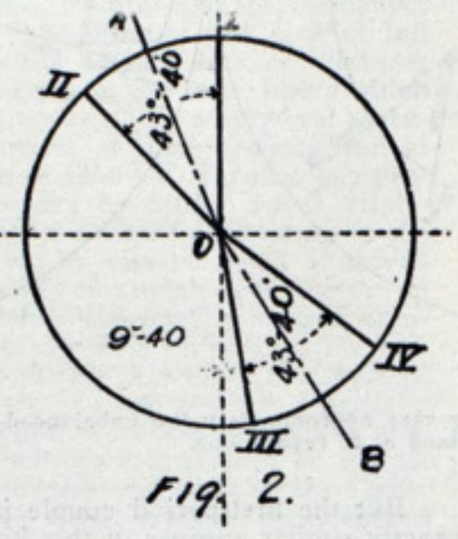


Fig. 2.

Fig. 1 gives the crank angles taken from Herr Schlick's paper "On Some Experiments Made on Board the Atlantic Liner Deutschland during her Trial Trip in June, 1900," read at the spring meeting, Institute Naval Architects, 1901. Fig. 2 gives the crank angles doubled. This brings cranks I and II both near top center when cranks III and IV are both near bottom center. The second period couple is, therefore, very large. If cranks I and II had lain in the direction OA, and cranks III and IV in the direction OB (these directions bisecting the angles between the pairs of cranks,) the second period couple would have been within half a per cent. of the greatest possible.**

In Fig. 2 the angles of the cranks give a couple, less than this in about the proportion cos $\frac{1}{2}$ (43°—40')=.928. (The exact value of this couple could only be found after knowing the masses attached to cranks I, II, III, and IV, but it would differ little from the above.) Thus the Y. S. T. system gives a second period couple not far from the worst possible; and this will be found always to be the case in this system. Herr Schlick's, 1900, Institute Naval Architects' paper was written to prove that, besides the first period balance, the force of second period could be balanced also. But as this force is always of small amount, surely its exact balance is of little importance when so large a couple is left unbalanced. Noticing these couples at the end of his paper, Herr Schlick says:

"It is evident from the foregoing that there always remains a small couple of forces, and it might be feared that these would cause vibrations. This is, however, in most cases, practically impossible. As in one revolution of the crank shaft two maxima and two minima of equal magnitude arise, therefore the vibrations of the longitudinal axis of the steamer could only be produced when the number of revolutions of the engine is only half that of the vibrations in the longitudinal axis, viz., when the engine is working dead slow. But with half the number of revolutions, the couples which arise are only one-fourth of the values given above."

Surely this is a remarkable statement. If true, would it not apply equally to the second period force? In which case the reason for the whole paper disappears; especially as, in all cases on the Y. S. T. system, the second period force is never more than a very small fraction of the greatest combined force of this period that the four cranks could exert, since the second period forces from the various cranks partly oppose one another; while, on the other hand, as just shown, the second period couple is near the greatest possible value. It may further be asked if any competent observer has ever seen a vibration diagram that did not give clear evidence of the simultaneous presence of more than one period of vibration, thus showing that the ship was vibrating in more than one mode at the same time; responding, on account of approximate synchronism, to unbalanced forces or couples of various periods? If so, would he say that the engine must run at half speed before there will be any response to the unbalanced second period couples? The above statement, indeed the reason for the whole of his paper, is more difficult to understand in view of a statement in his 1901 paper, that "most of the vessels supplied with my system of balanced engines have been run for trial with the propellers uncoupled to examine the effect of balancing; and on all these trials vibrations have never been noticed, even when the engine reached the critical number of revolutions, whereas engines not balanced always show excessive vibrations when running with disconnected propellers as soon as the critical number of revolutions is reached."

If this quotation was strictly accurate, it would be difficult to understand the object of writing a long paper to discuss the exact arrangement of cranks by which a small second period force may be annulled. The fact is, if our discussion thus far is correct, that engines on the Y. S. T. plan are not perfectly balanced, and we find it difficult to believe that they should not noticeably vibrate the ship when the propellers are disconnected, as it is alleged other unbalanced engines do, for this could only be explained by assuming that a lack of balance in the Y. S. T. engine produces a different effect from lack of balance in others. Very careful consideration of Herr Schlick's paper of 1901 fails to convince us of the correctness of his position, and it would require much more definite evidence than he adduces to establish the fact that the comparatively large effects shown by the vertical vibrations were due to the greater resistance experience by one blade of each propeller over that acting on the other blades. The propellers are, no doubt, of high class workmanship, and it is difficult to believe that any such marked difference in pitch or surface in one particular blade of each propeller would exist as is required in Herr Schlick's deductions. To be convincing, his paper should have given careful measurements of pitch and surface, which would have enabled his claims to be investigated numerically. These measurements could very readily have been made at any time the Deutschland was in dry dock. A slight diminution of pitch in the blades A, referred to in his paper, should have been accompanied by a disappearance of the first period vertical vibration, giving another easy confirmation of his theory, which ascribes the vibration of the Deutschland entirely to what must be considered very bad workmanship on the propeller. The comfort of the ship would also thereby have been increased. As further supporting the opposite view, that with a well-made propeller the vibrations almost entirely originate in the action of the engine, I may give the following quotation from Mr. Yarrow's 1892 paper:

"From our experiments we have overwhelming proof that the vibration of a torpedo boat is precisely the same in extent and character when the screw is on, and the vessel driven through the water, as when it is stationary and the engines simply revolving without doing work, the propeller being removed."

We have every reason to be certain that these large second-period couples, shown by Fig. 2, may vibrate the ship. That a ship responds readily to first-period couples can easily be proved. Thus, Mr. Yarrow, in a three-crank engine, made the moving weights of all three cylinders equal, thereby annulling, almost perfectly, the free force, but leaving the couple. He says, in his 1892 paper:

"Thus we prevented any vertical movements of the center of gravity of the engines; yet we found no improvement. This clearly indicates that the rocking vibrations are of more importance than the vertical vibrations in triple-expansion engines."

As proving the same, Mr. MacAlpine points to the experiments on H. M. S. Powerful and Terrible. If first-period couples are so important, why should it be reasonable absolutely to ignore second-period couples? From the large proportion of the reports one hears, ships having engines on the Y. S. T. plan seem to behave in the manner that the complete theory would lead us to expect.

I will now examine very approximately the unbalanced forces and moments of second and fourth period for the Deutschland. All the data used here will be found in Engineering for Nov. 23, 1900, and March 22, 1901. Fig. A, Plate III, gives the crank angles, and Fig. D the crank centers in millimeters, and feet and inches, and the cylinders worked from each crank. The size of the engine is:

Diameter of two H.P. cylinders,	930 mm.=	36.61 in.
Diameter first Int. cylinders,	1870 mm.=	73.6 in.
Diameter second Int cylinders,	2640 mm.=	103.9 in.
Diameter two L.P. cylinders	2700 mm.=	106.3 in.
Stroke of pistons,	1850 mm.=	72.8 in.

Connecting rod=4 cranks.

The weights of the moving parts for cranks II and III were calculated from the general arrangement of engine, and cylinder and crank shaft details, published in Engineering. They can only be looked on as approximate, but the details are given to so large size and so fully dimensioned that an error of more than from 5 to 10 per cent. is improbable. The mass taken—32 tons—is probably a little under the truth. The comparatively small effects from the valve gears are omitted here. The engine is supposed to be running at ninety revolutions per minute, giving a piston speed of 1092 ft. per minute, which is about that usually maintained in the Atlantic greyhounds.

$$w = \frac{90 \times 2\pi}{60} = 9.4248\, w^2 = 88.8.$$

m_1 for cranks II and III=32 tons.
r=72.8÷12, feet.

$$\frac{m w^2 r}{g} = \frac{32 \times 88.8 \times 72.8}{12 \times 32.2} = 268 \text{ tons;}$$

the highest inertia force of first period for cranks II and III.

If we take all moments about crank I we have:
Maximum value of moment for crank II=268×11.5=3082 ft. tons.
Maximum value of moment for crank III=268×30½=8263 ft. tons.

We can now determine the other moments and forces, necessary for first period balance, from Fig. A. Lay off oa to represent to scale 8263 ft. tons. Draw ab parallel to crank IV and produce crank II in ob. ob then represents the necessary moment for crank II and ab that for crank IV.

ob=3082 ft. tons.
ab=7900 ft. tons.

It may be noted that the data we are using is redundant. That it does not give us any trouble is proof that the crank angles have been correctly determined. I need not stop to remark on the data necessary and sufficient to make the required determination in any case. That will be found discussed in some of the papers referred to above.

The force for crank IV is $\frac{7900}{42\frac{1}{3}}$=186.6 tons, 42⅓ being the arm of the moment. (See Fig. D.) Now draw the force polygon ocdeo, Fig. A, by making the sides proportional to the forces for the several cranks, to which they are paralled. We find eo=186 tons. Higher period forces and moments.

Only the parts having the same motion as the crosshead, and a part of the connecting rod*** give rise to these shorter period forces. The mass of these parts for the Deutschland is about 20 tons for each of the cranks II and III, or ⅝ of the mass producing first period forces. Light counterbalances on cranks I and IV make the proportionate reduction for these cranks about the same. Again, the connecting-rod length being four cranks, the coefficients in the infinite series of equation (14) apply to this

**Cos ½ AOB = — cos ½ (9°—40') = — .996. If AOB had been in a straight line, the couple would, obviously, have been the largest possible.

***The proportion of the whole rod to be taken is the ratio which the distance between the center of gravity of the rod and the center of crank-pin bears to the whole length of the rod.

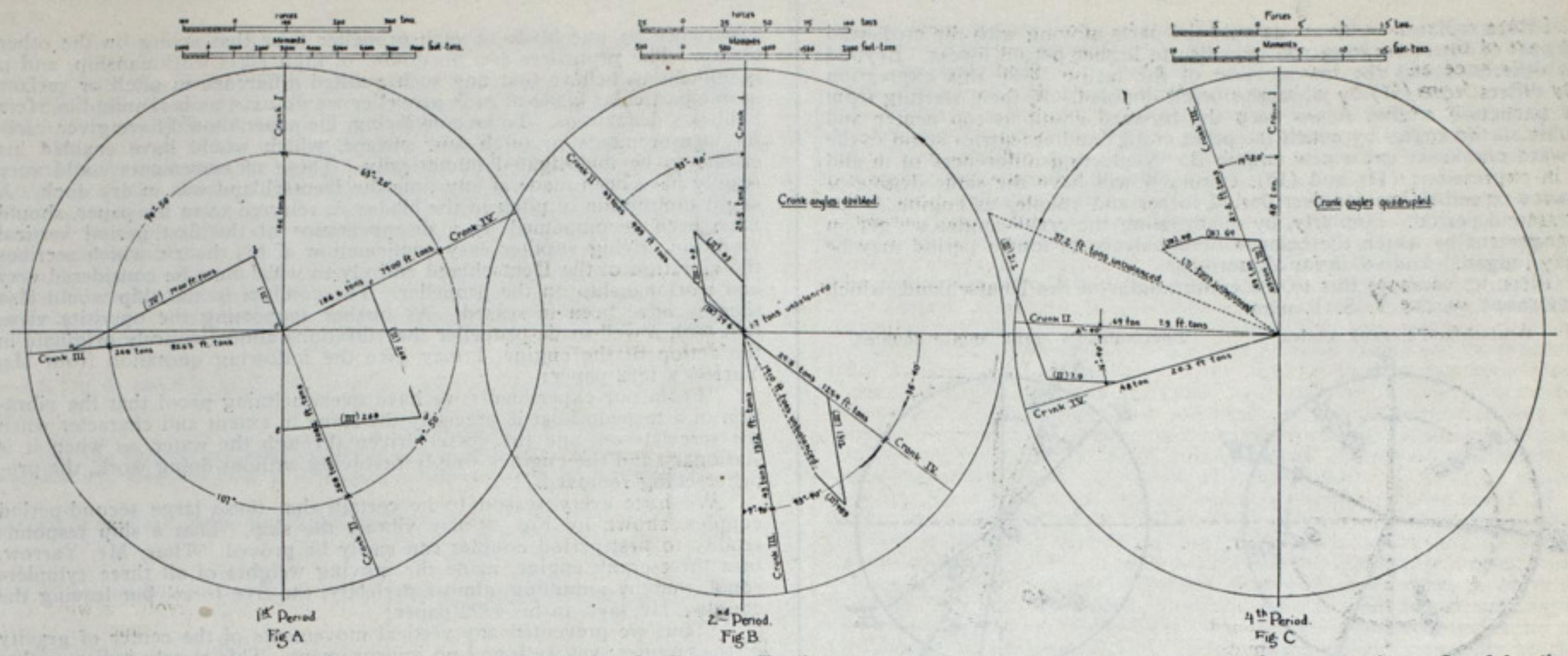


Plate 3. Four-Crank Engine balanced on Yarrow-Schlick-Tweedy System.—Showing very approximately the unbalanced forces and moments of second and fourth periods for steamship Deutschland at 90 revolutions.

case. Thus for second period we must multiply the forces and moments for the four cranks in Fig. A by 5/8 for the reduction of mass, and by .2540, the coefficient in equation (14). For fourth period the multipliers are 5/8 and .0041.

Second Period.	Force.	Moment.
Crank I	186 × .2540 × 5/8 = 29.5 tons.	Zero.
Crank II	268 × .2540 × 5/8 = 43 tons.	3082 × .2540 × 5/8 = 489 ft. tons.
Crank III	268 × .2540 × 5/8 = 43 tons.	8263 × .2540 × 5/8 = 1312 ft. tons.
Crank IV	186.6 × .2540 × 5/8 = 29.6 tons.	7900 × .2540 × 5/8 = 1254 ft. tons.
Fourth Period.	**Force.**	**Moment.**
Crank I	186 × .0041 × 5/8 = .48 tons.	Zero.
Crank II	268 × .0041 × 5/8 = .69 tons.	3082 × .0041 × 5/8 = 7.9 ft. tons.
Crank III	268 × .0041 × 5/8 = .69 tons.	8263 × .0041 × 5/8 = 21.2 ft. tons.
Crank IV	186.6 × .0041 × 5/8 = .48 tons.	7900 × .0041 × 5/8 = 22.2 ft. tons.

Figs. B and C gives the crank angles doubled and quadrupled, respectively. The above forces and moments are laid off parallel to the corresponding cranks, as in Fig. A, but in Figs. B and C the polygons do not close, showing that the engine is unbalanced for second and fourth period. The defect of balance is:

	Force.	Moment.
Second period	1.7 tons.	1910 ft. tons.
Fourth period	1.71 tons.	37.2 ft. tons.

These values are for one engine only.

Second Period—The force is quite unimportant, but the moment is very great. It is strange that Mr. Schlick should have devoted his elaborate paper of 1900 to showing how this force could be reduced to zero, and have passed over the moment as quite negligible. The importance of forces and moments of a given value is greater the shorter their period, since the shorter the period the more quickly will energy of vibration be supplied, other things being equal. Just as an engine running fast will give more horse-power from the same steam loads than the same engine running slow. Thus 1,910 ft. tons of second period is as important as a much larger moment of first period.

Fourth Period—The remark just made applies with greater force to this period. Besides, these forces and moments are here estimated for a perfectly rigid foundation. They are due to large masses with an extremely small amplitude of vibration. Whenever the ship responds their values will increase, and we can readily see that in the case of fourth or higher period, where the original amplitude is minute, the response from the ship may be such as to increase the exciting forces and moments many times. Also, as a vibration becomes more rapid, the amplitude, which can be tolerated, diminishes very quickly. This great increase of amplitude cannot, of course, occur where the original amplitude is comparatively large, as in the first and second periods. The full discussion of the question is very difficult, but we can readily see that forces of a high period must not be treated as negligible, because they are relatively small. Experience shows that they give rise to very sensible effects.

Let us now notice an engine proposed by Messrs. Robinson and Sankey in a paper read before the Institute of Naval Architects in 1895. If we make a three-crank engine with cranks at 120°, and all the masses, m, attached to each crank equal, the first period force will be zero. For it is

$$\frac{mw^2R}{g}\{\cos\phi + \cos(\phi + 120°) + \cos(\phi - 120°)\}$$

$$= \frac{mw^2R}{g} \times \cos\phi\,(1 + 2\cos 120°) = 0, \text{ since } \cos 120° = -\tfrac{1}{2}.$$

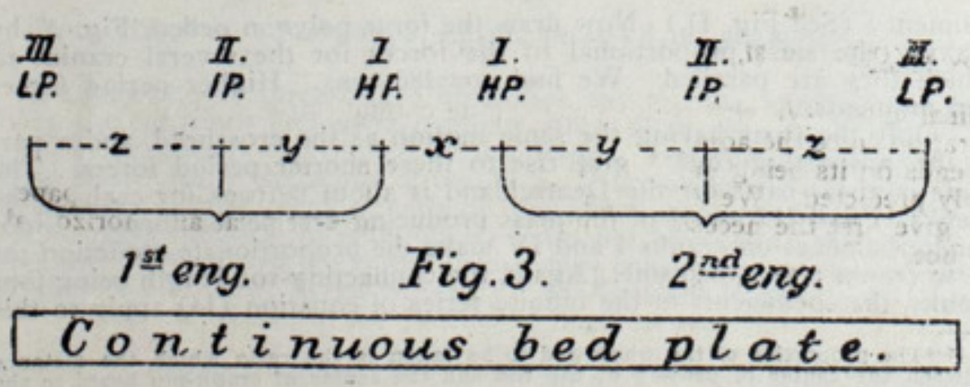
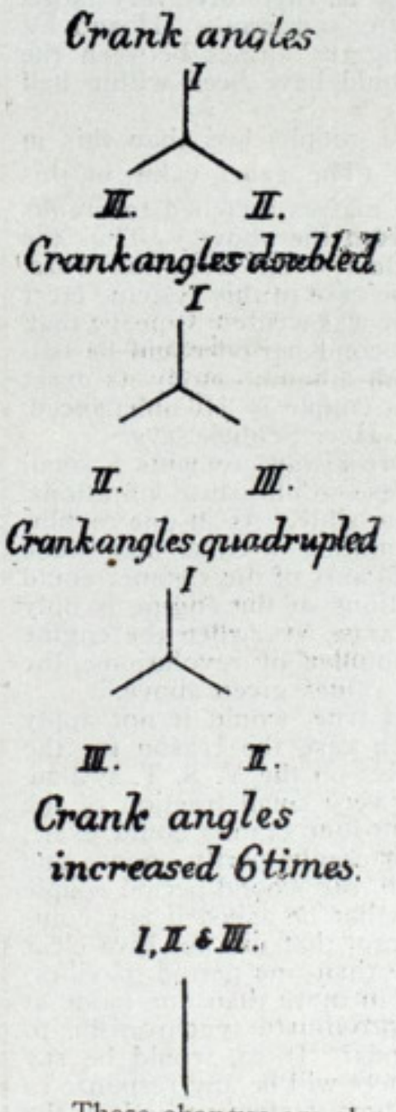


Fig. 3.

Continuous bed plate.

But the first-period couple is obviously not zero. Now mount two exactly similar engines of this kind, but right and left hand, on one bedplate, Fig. 3. Corresponding cylinders, say the H.P., are to be contiguous, so that the cylinder centers, if not equal, may be symmetrically placed. Couple the shafts so that the contiguous cranks of the two engines pass top center at the same time. Then will the center cranks of each engine pass top center together, and also the outer cranks.



First period forces are zero. First period couples from each engine exactly oppose, and are therefore zero for the combination; that is, the first period balance is exact.

Double the crank angles and we get exactly the same arrangement of cranks, but left-handed. Hence the second period balance is exact.

Quadruple the original crank angles and we get the original arrangement. Hence the fourth period balance is exact.

Increase the original crank angles six times and all the cranks come into one plane. Hence there is the maximum unbalanced force of sixth period. And so on.

These changes are shown in Fig. 4. If we could bring these engines together till the two contiguous cranks were one, actuating a mass 2m, the six-cylinder engine would become a five-cylinder, with balance up to and including the fourth period. These engines have found almost no favor, and are not likely to, as they must be very costly and long. Space is too valuable on board ship. Their balance is, however, much more exact than can be obtained with four cranks.

Mr. MacAlpine lays much stress upon the fact that calculations for balance of the four, five, or six-crank engines, and also for the revolving counterbalances at the ends of the engine, proceed on the assumption that the ship is rigid over the length of the engines, and that the assumption is specially inadmissible when considering the shorter period vibrations; in fact, that the whole question is one of the elasticity of the ship. It is not unnatural that he should notice the point, as the balance of the engine he proposes does not involve this assumption to anything like the same extent, but I cannot think that this point is of more than the most secondary importance.

Before proceeding to consider in detail the MacAlpine system of balancing, and in order that we may not omit any system which has a legitimate claim to be considered in relation to the balancing problem, we may give some thought to the steam turbine. The splendid work done by the Hon. C. A. Parsons in the development of this form of motor, and the remarkable success which has attained its application to torpedo vessels in the way of securing extraordinary speeds, has led many enthusiastic members of the profession to believe that this motor is destined ultimately to

supplant the reciprocating engine. With a view to give it a fair trial, Messrs. Denny built the excursion steamer King Edward, which has recently been put in service on the river Clyde. Nearly all of the published accounts of trial trips of torpedo-boats have called particular attention to the marked absence of vibration at high speeds, so that this has already been advanced as a strong argument in favor of the adoption of the turbine. In addition to others which have been given, it should be stated at once that the turbine is perfectly balanced, for it would be impossible to run it at the high speeds necessary, unless it were in perfect dynamical balance. It is to be noted, however, that there are some very serious drawbacks to the steam turbine, as far as it has now been developed, for general use as a marine engine. One is the difficulty of reversing, and, as is well known, the vessel is driven astern not by the same turbines which give the ahead motion, but by independent ones which, from the necessities of the case, are much smaller and give only a relatively low speed. It has been asserted by many that the recent loss of the Viper, from whose performances so much information was expected, was on account of this lack of full power for reversing. Another objection is the decided lack of economy at very low powers. While this might not apply to the large liners which run at nearly constant speed throughout the voyage, it is a very real objection to use on war vessels which, during most of their cruising run at about one-tenth of their full power. It is true that Mr. Parsons has proposed to increase the efficiency at low powers by fitting small triple-expansion engines forward of the turbines with a clutch connection to the main shaft. This proposal, however, can hardly receive much approval, for the reason that it would introduce altogether too much complication of machinery. I understand, moreover, that while the turbine itself is completely balanced and there is no vibration of the ship forward of the turbines, experience on the King Edward has shown that there is a decided vibration which increases from amidships aft. In the saloons, especially in the lower or dining saloon, the vibration and noise are very great, and, indeed, at the after end of the saloon the vibration is said to be almost unbearable. In this respect, this vessel is probably the worst on the Clyde. This vibration is partly due to the propellers, for it must be remembered

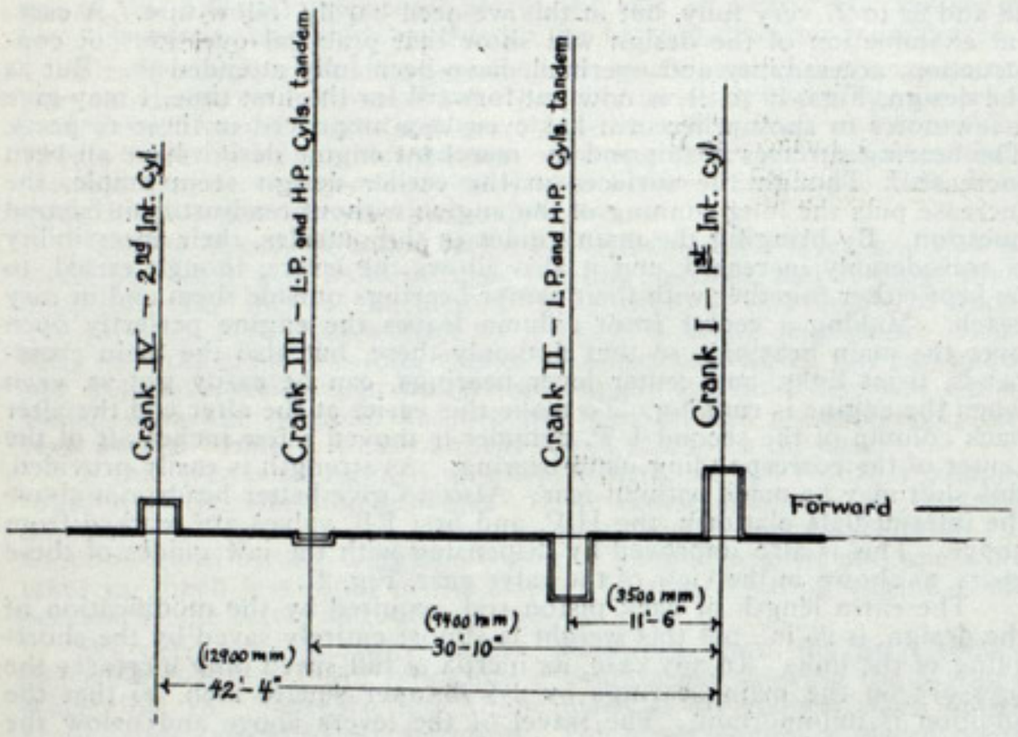


Plate 3. Crank Centers

Fig. D

that the speed of revolution is abnormal compared with that of ordinary vessels, and a degree of balance which would be considered perfect in a propeller running at ordinary speed would be inadmissible for these very high-speed cases. In any event, the steam turbine is at present entirely in the experimental stage, and whatever its future development may be there can be no question that we shall go on building reciprocating engines for a great many years to come. Consequently, from the standpoint of actual practice, the turbine cannot be considered a practical solution of the balancing question.

Let us now consider Mr. MacAlpine's solution of the vibration problem, taking largely as a guide his recent paper, read before the Institute of Naval Architects this year in their summer meetings in Glasgow. We have seen, earlier in this paper, that only partial balance can be attained by direct-connected four-crank engines; and that, though the solution with five and six-crank engines is much more nearly perfect, there are great practical objections to their general adoption. The complete solution, then, is not to be attained by direct-connected engines of the usual type. There is still one solution with the connecting-rod engine, and it is unique. Add to the right-hand side of equation (14) an expression—

$$-\frac{mw^2r}{g}(\cos\phi + .2540\cos 2\phi - .0041\cos 4\phi + .00007\cos 6\phi + \text{etc.}) \qquad (16)$$

Make $MR=mr$

and we at once have $F=O$.

This solution is realized with the most complete success in one of the Watson and Billetop balanced engines. It is a four-cylinder engine. Pairs of cylinders are placed exactly in line, but on opposite sides of the crank shaft. The cranks for opposite cylinders are exactly opposite, so that the motions of the pistons are exactly the same, but in opposite directions. This makes the addition of expression (16) to the corresponding expression in (14), as directed above. In Engineering of July 5, 1901, p. 7, Mr. Billetop writes:

"During the tests, the engines were not held down by bolts or fixtures of any kind, and a glass filled with water and placed on top of the cylinders did not show the slightest surface tremor when running under those conditions."

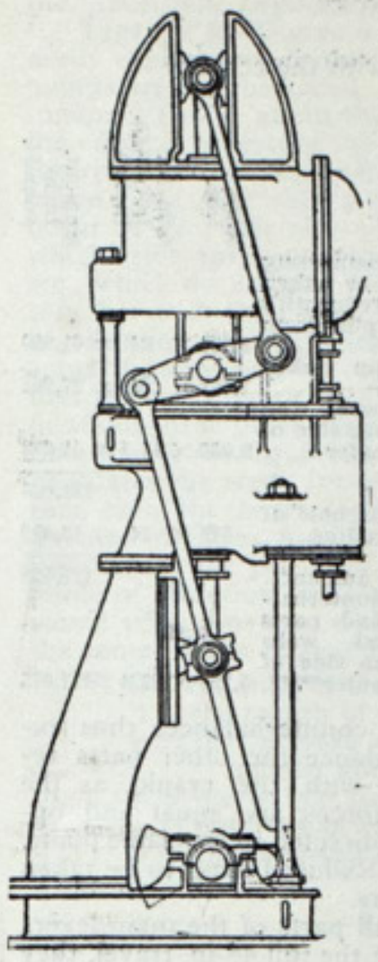


Fig. 6.

Fig. 6 also shows, roughly, a design of engine in which this solution is realized. The counterbalance on the shaft balances the inertia of the crank and part of the connecting rod. The rest of the lower moving parts are balanced by the oppositely moving upper parts. By making these adjustments correct, the vertical and horizontal balance can be made exact.

Figs. 7 to 18, Plate 1, show a design which Mr. MacAlpine gives in his paper, but which he has now improved on. He points out that the motion of the back piston is not absolutely the reverse of that of the piston over the shaft. The difference of displacement is, however, never more than a very small fraction of an inch, and I retain the design as a very approximate solution, though I am entirely satisfied that the modification in Figs. 19 to 21, Plate 2, is to be preferred, not only because it gives a perfectly exact solution, but for purely practical questions of design. Figs. 22 to 27, Plate 3, show another form of exact solution only suitable for merchant ships where there is ample headroom.

In each of these designs a comparatively light counterbalance on the crank exactly balances it and the other parts revolving with it. The horizontal forces are thus balanced. The reciprocating masses, moving oppositely in the pairs of cylinders, can also be adjusted so as to balance. In the designs shown the stroke of piston for each cylinder is equal, so that what is required is to make these oppositely reciprocating masses exactly equal. The calculations for the design, Figs. 7 to 18, Plate 1, I append, to bring out all the details that have to be attended to. I do not give the figures for the other designs, as these given are inserted merely to act as a guide to those calculations which will have to be repeated for each new design as it is made.

But we are left with an unbalanced inertia torsional couple, since the connected pairs of pistons, etc., do not move in the same vertical line. By placing the cylinders tandem or adding a third cylinder on the other side of the vertical line through the shaft, connecting it also by a lever, this increase of the unbalanced torsional couple is avoided. But these arrangements are not to be commended for shipboard, and I will show that the simpler design is justified by the small effect of the unbalanced torsional couple. This effect will be to vibrate the ship torsionally about a longi-

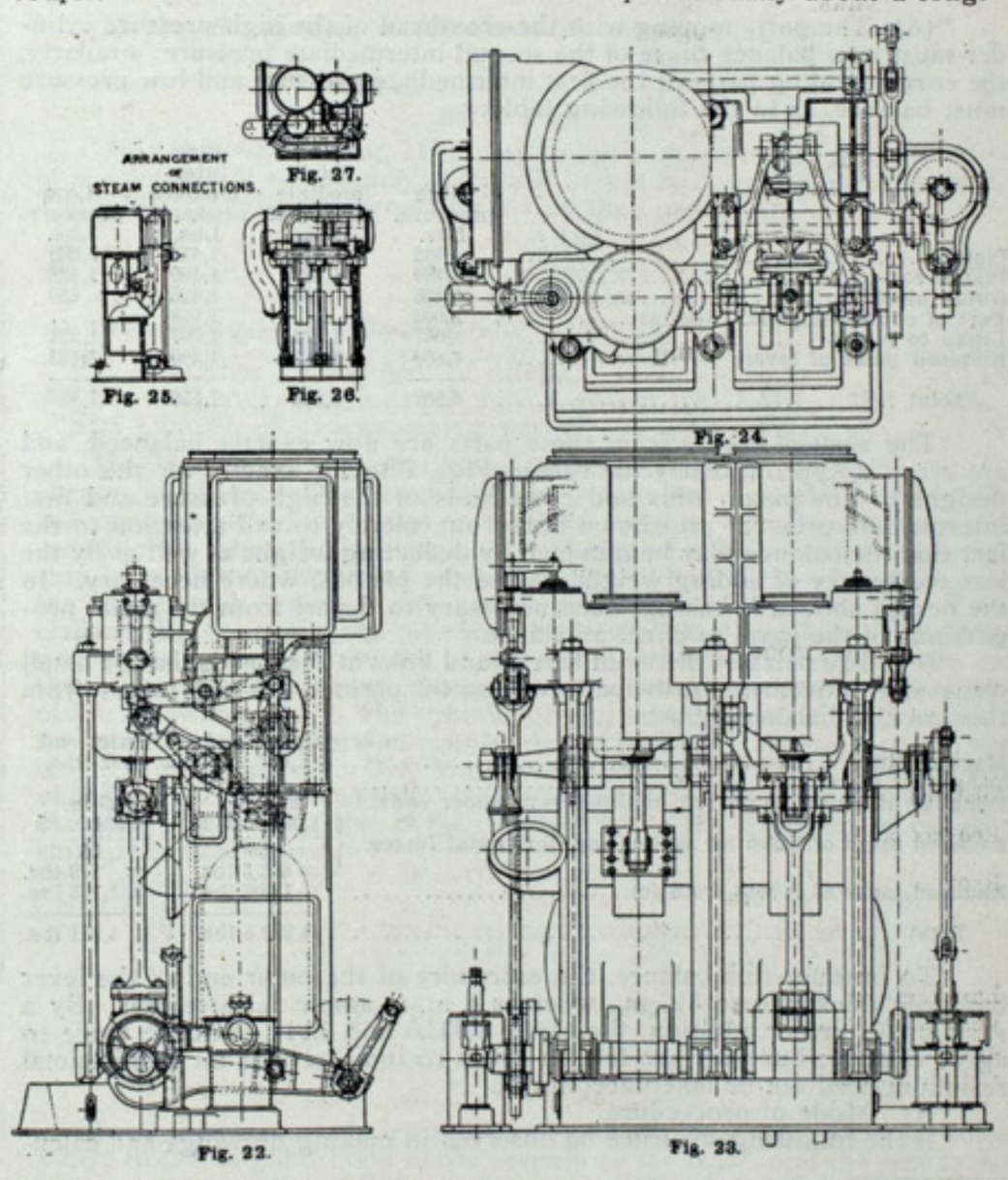


Plate 4. Cylinders 27, 39, 56 and 80 in. by 48 in. stroke; boiler pressure, 200 lbs.

tudinal axis. We will require to examine carefully the magnitude of this vibration since the admissibility of the engine as a solution of the problem depends on its being exceedingly small. This magnitude is, happily, very easily predicted. We will leave this question till near the end of the paper and give first the necessary adjustments for exact vertical and horizontal balance.

"Cylinders 27 in., 39 in., 56 in., and 80 in. diameter.

"Stroke, 48 in.

"Boiler pressure, 200 lbs. per square inch.

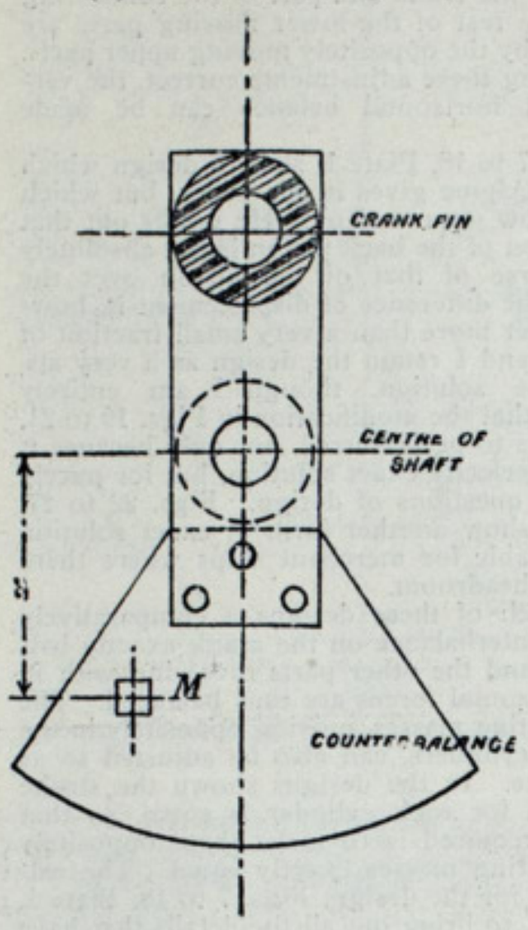
"Designed piston speed, 900 ft. per minute.

"Revolutions, 112.5 per minute.

CALCULATIONS FOR BALANCES.

"(a) Connecting rod****:

"(b) Counterbalancing the parts revolving with the crank:



	Mass. Lbs.	Arm for Leverage. Inches.	Moment. Inch-pounds.
Part of connecting rod to be taken as revolving with crank pin—from (a)	2,580 ×	24	= 61,920
Crank pin taken as solid	1,158 ×	24	= 27,792
Crank webs on crank pin side of shaft center	2,930 ×	14.1	= 41,313
			131,025
Deduct for hole at crank radius	579 ×	24	= 13,896
Total amount..			117,129
Two counterbalances and parts of crank webs on same side of shaft center*****.	5,250 ×	22.3	= 117,075

"The counterbalances thus exactly balance the other parts revolving with the crank, as the inertia forces are equal and oppositely directed in the same plane.

"(c) Reduced mass to be taken for levers.

"As all parts of the main levers have not the full 48-in. travel, they must be taken at a reduced weight, the moment of each end being reckoned from the rocking center and the arm being measured parallel to the center line of the lever, similarly to the calculation for the counterbalances in (b), above.

	Crank end of lever.	Outer end of lever.
Length between rocking center and end centers	39 in.	39 in.
Mass	2,482 lbs.	2,123 lbs.
Moment	54,604 in.-lbs.	44,160 in.-lbs.
Arm = moment ÷ mass	22 in.	20.8 in.
Reduced mass	$\frac{2,482 \times 22}{39}$ = 1,400 lbs.	$\frac{2,123 \times 20.8}{39}$ = 1,132 lbs.

"(d) The parts moving with the crosshead of the high-pressure cylinder must now balance those of the second intermediate pressure; similarly, the corresponding parts of the first intermediate pressure and low pressure must balance, as in the following table:

	High pressure. Lbs.	Second intermediate pressure. Lbs.	First intermediate pressure. Lbs.	Low pressure. Lbs.
Piston	662	2,329	1,416	3,083
Piston rod	1,180	1,428	1,180	1,428
Guide block	1,425	689	1,425	689
Part of connecting rod. See (a)	1,068	.....	1,068	.....
Links to levers	1,067	1,224	1,067	1,224
Reduced mass of levers	1,400	1,132	1,400	1,132
Total	6,802	6,802	7,556	7,556

"The vertical forces from these parts are now exactly balanced, and are zero. (Approximately for design Figs. 7 to 18; exactly for the other designs.) The piston rods and crossheads of the high pressure and first intermediate pressure are shown bored out, merely to call attention to the fact that the balance may be obtained by deducting weight as well as by the less costly way of adding weight, say to the pistons, where necessary. In the design shown, it has not been necessary to depart from the usual proportions of the parts to effect a balance.

"(e) The parts of the main levers, and links at their ends, have a small transverse movement, principally of second period; but the forces from this are also balanced thus:

	Crank end.	Outer end.
Mass of links	1,067 lbs.	1,224 lbs.
Length of links	55 in	55 in.
Distance of center of gravity of links from upper ends	27.5 in.	35 in.
Reduced mass of links for estimating horizontal forces	$\frac{1,067 \times 27.5}{55}$ = 533.5 lbs.	$\frac{1,224 \times 35}{55}$ = 779 lbs.
Reduced mass of levers from (c)	= 1,400 lbs.	= 1,132 lbs.
Total	1,933.5 lbs.	1,911 lbs.

"To produce this balance, the extremity of the outer end of the lever has been thickened to 5½ in., whereas 4 in. is ample for strength. By a very small further addition, the totals 1,933.5 and 1,911 could be made to agree exactly; but they are left, in order to indicate that an infinitesimal residuum need not be taken account of.

"(f) Mode of proceedure.

"If the following sequence be observed in making drawings and calculations, no further delay need be incurred in the design than the time required to make a few simple calculations.

"(1) After the crank shaft and connecting rod are drawn, calculate and draw the counterbalance of the requisite size.

"(2) After the main levers and their links are drawn, make any slight addition required to one or other end of the levers to produce horizontal balance, as in (e).

"(3) After all the other moving parts are drawn, add to one or other of the balancing pistons sufficient to make exact balance, as in (d).

"This also suggests the proper mode of procedure in building the engine. A little metal should be left on each piston till all the other moving parts are finished and weighed, after which the requisite amounts of metal should be taken off to produce the exact required balance.

"(g) The balance of the valve gears is obtained in precisely the same way as in the foregoing. But it would be ample to make—

Reduced mass of ahead eccentric.....
+ ahead strap and rod.....
+ (say) ½ link .....
+ ½ drag-rod .....
+ valve-spindle .....
+ reduced mass of crank end of levers..
+ high-pressure valve .....
= Reduced mass of outer end of levers
+ crosshead
+ valve spindles
+ 2d intermediate pressure valves.

"And, similarly, for the first intermediate pressure and low-pressure gear."

Obtaining an exact vertical and horizontal balance for all periods will prevent those short vibrations or tremors which are not only annoying, but must make the correct aiming of a gun much more difficult. The alternative and modified designs, Figs. 16 to 21, show the clearances of the steam passages in the cylinders over the cranks reduced to a minimum; the engine will thus be brought up to the highest efficiency of any modern marine engine. The counterbalances marked "G," Fig. 16, are added to bring the inertia of the valves of these cylinders into the plane of the valve levers.

Mr. MacAlpine discusses the various points of the designs Figs. 7 to 18 and 22 to 27 very fully, but in this we need hardly follow him. A careful examination of the design will show that practical questions of construction, accessibility and overhaul, have been fully attended to. But as the design, Figs. 19 to 21, is now put forward for the first time, I may give a few notes to show wherein it has even been improved in these respects. The bearing surfaces in this and the merchant engine design have all been increased. Though the surfaces in the earlier design seem ample, the increase puts the long running of the engine without readjustment beyond question. By bringing the main guides to the outsides, their accessibility is considerably increased, and it also allows the levers, though raised, to be kept closer together with their center bearings outside them and in easy reach. Making a center front column leaves the engine perfectly open over the main bearings, so that not only these, but also the main crossheads, front links, and center lever bearings, can be easily got at, even when the engine is running. To make this easier at the after end the after back column of the second I. P. cylinder is moved a few inches aft of the center of the corresponding main bearing. As strength is easily provided, this shift may be made without fear. Also, to give better headroom above the intermediate platform, the H.P. and first I.P. valves are worked from above. This is also improved by dispensing with the jaw guides of these gears, as shown in the view of the valve gear, Fig. 21.

The extra length of back piston rod, required by the modification of the design, is 25 in., but this weight is almost entirely saved by the shortening of the links. In any case, its inertia at full speed only increases the pressure on the main bearings by 2½ lbs. per square inch, so that the addition is unimportant. The travel of the levers above and below the horizontal position is made unequal. This in no way affects the balance, but by preventing the lever and links from drawing so nearly into line when the crank is at the top makes the adjustment of the whole connection less delicate. The links have also been so designed that they can be kept exactly to length. The levers can readily be withdrawn to the back. The back links and glands of back cylinders are in easy reach. The crossties are attached so that the expansion of the cylinders will have no sensible effect. Some of the weight saved by bringing down the back cylinders is added to the front columns and some to the front of the bed-plate, so that the total is not much altered. The front cylinders are held from fore-and-aft movement by a jaw cast on the L. P. cylinder, which holds, by sliding contact only and without bolting, the foot for the center back column of the front cylinders. The front of the engine may now be toward the center of the ship, as is usually most convenient; and the hatches, instead of coming close together, will leave a wide passage on deck between them. The hatches do not now require to come much beyond the center of the back cylinders, which will leave these openings of about the ordinary width, and give broad side passages on deck. The H.P. and first I.P. valves draw up, those of the second I.P. and L.P. draw down. This not only suits the design, but also the narrower hatches. Is it admissible to introduce the lever into high-speed engines? So far as the valve gear is concerned there are ample precedents, and consequently there can be no question. Not only has the Stephenson link been used with an almost identical arrangement of lever, but we have in the Marshall gear quite as indirect a connection, and in the Heusinger-von-Waldegg gear one much more indirect. But these are good gears, and only require to be well and carefully designed to give great satisfaction.

In regard to the levers connecting the back cylinders, Mr. MacAlpine gives an elaborate defence of their introduction. In Britain, the beam engine is rarely or never seen on board ships, but we cannot cross our ferries or sail up our broad rivers, or take a summer trip up Long Island sound without being for the time shipmates with one, thus having ample time to become acquainted with their good qualities. The piston speed—and it is principally piston speed that counts—runs sometimes as high as 1,000 ft. per minute, and the beam works often to a great angle. There is no smoother working engine made, and it is the most economical in the use of lubricants of any engine known; and the chief engineer may often be seen sitting in his easy chair, the picture of unconcern.

Mr. MacAlpine quotes our experience, and, having lived for six years with us—having had the misfortune to just miss being turned into a good citizen of our Republic—ought to know. The beam engine forming part of our earliest recollections and of our maturest experience, we hardly need the arguments he adduces to convince us. He speaks of the number of joints between the piston and crank. He has precisely the same number

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****For the reason of this calculation, see "Analysis of the Inertia Forces of the Moving Parts of an Engine," by the present writer: Engineering, Vol. LXIV, p. 513, remarks after equations (15) and (17); or, Journal of the American Society of Naval Engineers, Vol. IX, p. 513, remarks after equations (83) and (85).

One connecting rod	= 3,648 lbs.
Length between centers, 9 ft	= 108 in.
Center of gravity of rod from crosshead	= 76.38 in.
Part of connecting rod to be taken as revolving with crank pin	$= 3,648 \times \frac{76.38}{108}$ = 2,580 lbs.
Part of connecting rod to be taken as reciprocating with crosshead	3,648 — 2,580 = 1,068 lbs.

*****Obviously, in counting the moment for the counterbalances, the sum to be taken is ΣMx, where M is any small portion of the mass and x its distance from the shaft center, measured parallel to the crank radius. See sketch.

as in our beam engines, and we experience no trouble. It is all a question of bearing surface.

In our original Chicago we had, to the writer's mind, the worst designed beam engine ever put on board a ship, with unbalanced walking beam, with grasshopper long and short-ended beams to suit a long-stroked engine and a short-stroked crank. Yet these engines were worked as high as seventy-two revolutions per minute, or 684 ft. piston speed, without any great degree of discomfort, except for the heating of the bearings and beam centers, because they were out of all proportion to the work they had to do. After the experience which the navy had with such an abortion of a design, I would not hesitate to build and run a properly proportioned and balanced engine on the MacAlpine design as high as 1,000 ft. piston speed or 100 or 120 revolutions per minute.

Here are the pressures from steam on the various bearings in the first and latest designs, Figs. 7 to 18 and 19 to 21, respectively. Maximum total pressure on each piston—67,400 lbs. = 30 tons.

	Pounds per square inch. First design Figs. 7 to 18.	Latest design Figs. 19 to 21.
Main bearings	200	173
Crank pin	440	366
High pressure and first intermediate pressure crosshead bearings	842	454
High pressure and first intermediate pressure guide blocks	48	48
Bearings of links to levers	802	468
Center bearings of main levers	560	344
Second intermediate pressure and low pressure guide blocks	15	25

The pressures in the first column should be perfectly satisfactory, but the larger bearings were introduced into the two last designs to anticipate any possible criticism. These pressures will very safely allow for any slight increase of the inertia due to the additional parts (that is, the links and reduced mass of the levers) making connection to the back crosshead, and also meet all demands for long wear and smooth running. For it should be recollected that a reduction of bearing pressure, by allowing a thicker oil film, very quickly reduces the rate of wear—reduction of pressure to one-half far more than halves the rate of wear. The thicker oil film also keeps down friction, though the bearing diameter is increased.

Mr. MacAlpine also discusses the increased elasticity of the connection over the direct connection and the possible unsteady working, the whole gear being thrown into vibration. Make it stiff enough and it will not vibrate. Our beam engines do not. Leaving the rest of his argument—which I think perfectly sound—to those who are weak in the faith, I will quote his last sentences in this connection:

"Finally, it may be asked, What is the crank but a lever, and that not of the best kind, with its large span, rotating journals, and bearings whose diameters bear such a considerable proportion to the length of crank? The proposal is to replace these by levers of a better description. In the early days the crank was long viewed with distrust—which was unfounded; and, I believe, misgivings which some might entertain here will quickly vanish when the proposal has become familiar, and its advantages have been weiged. Indeed, I have already found this to be the case."

If the lever is all right, if we adopt it here, we can realize a complete solution of the vibration problem. If we decide against it we can make no further progress in this direction with the reciprocating engine. Its adoption gives us also a lighter engine, a simpler engine, and one which takes up much less room in the ship. The non-vibrating engine is also necessarily the better and safer to run.

We need not enumerate, as Mr. MacAlpine does, the parts reduced and simplified, but I will reproduce a comparison showing the saving of space, Fig. 28. This Mr. MacAlpine made at my request when he first brought his system to my attention. The lower engine is placed on the

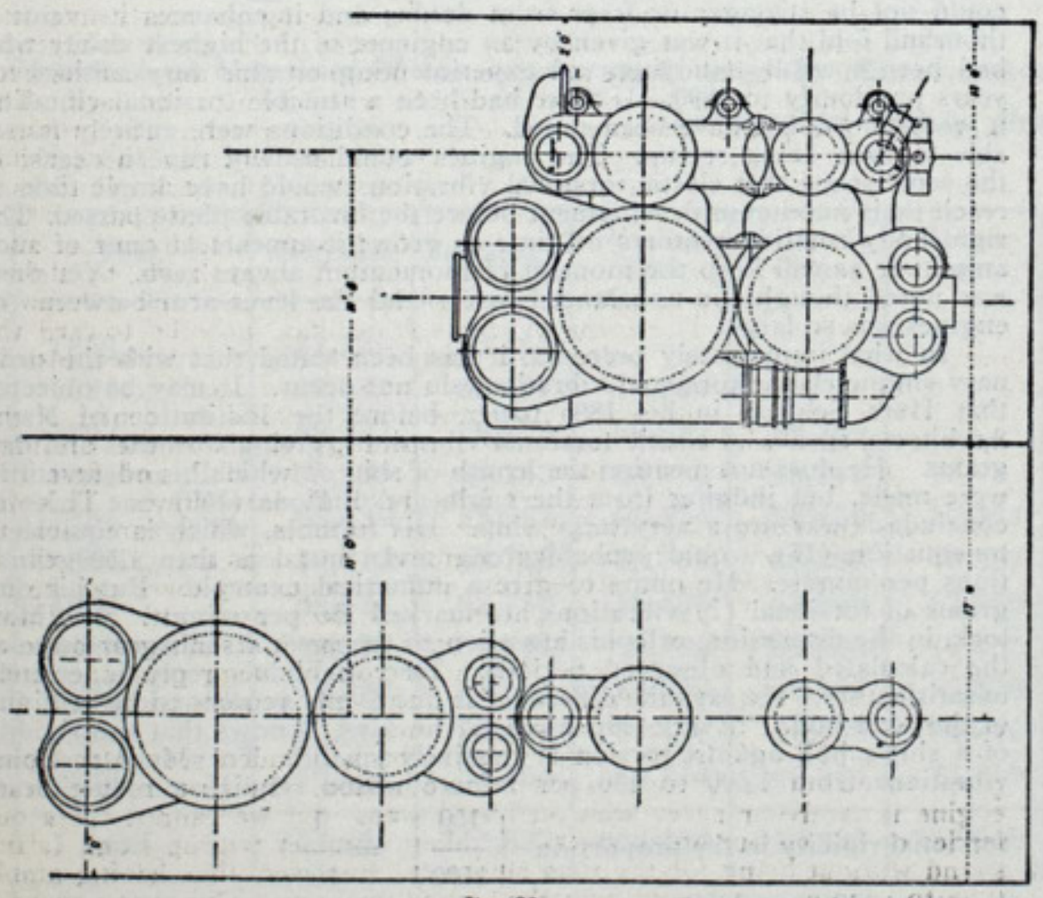

FIG. 28.

same center line, 11 ft. 0 in. from the center bulkhead, as the engine of one of our ships. This engine is actually shortened up to the length required for a crank shaft made in two pieces instead of four. The upper engine is reduced from Fig. 16. We might bring the lower engine nearer the center bulkhead, thus making a slightly narrower engine-room than that required for the upper engine, but the length and total space occupied by the upper engine is much smaller than for the usual design. This was well illustrated by plans the engineer-in-chief made proposing triple screws for some of our recent ships. While the triple screw arrangement was hardly possible with the ordinary four-crank engine, it went in very nicely with the MacAlpine engine.

Figs. 22 to 27 give a design of merchant ship engine which scarcely needs explanation further than to point out that the moving parts of the pumps are also balanced. As noted earlier, it is not sought to balance the torsional couple about the crank shaft, as Mr. MacAlpine has shown that the effect in vibrating the ship is excessively small. I will only transcribe the results, referring to the original paper for the full details of the calculation. He first shows that sensible elastic torsional vibration will not occur at all. The ship is composed of parts such as the skin and decks which give torsional rigidity, together with machinery and woodwork, etc., which do not add sensibly to the elastic reaction. These latter parts, together with the cargo, add to the moment of the inertia about the axis of vibration, and thus lengthen the period of torsional vibration. From actual figures supplied by Prof. F. P. Purvis, Mr. MacAlpine concludes that the total moment of inertia of a ship will range from a higher limit of about three times that due to the parts giving torsional rigidity, to less than twice; the figures for warships being nearer the lower limit. But he calculates the result for an increase of two, three, and four times, showing that even the latter high value would not effect his argument for the absence of elastic torsional vibrations. He then gives the ordinary investigation for the period of torsional vibration of a circular tube or bar, the mode of vibration being that with two nodes, as these are the slowest torsional vibrations into which a ship would be thrown by couples applied at the center by an engine placed there.

If T = the time of a complete vibration in seconds;
l = the length of the tube in feet;
n = the increase of moment of inertia (2, 3, and 4 times) as explained above.
p = the weight per cubic foot of the elastic material of the tube.
q = modulus of rigidity.
g = the intensity of gravity = 32.2.

Then,

$$T = l\sqrt{\frac{n\rho}{g\mu}}, \qquad (17)$$

when there are two nodes. The speed of vibration is independent of the diameter of the tube.

I will quote the numerical results from Mr. MacAlpine's paper, making the requisite changes in the numbering of his equations.

"ρ for steel = 500 lbs. per cubic foot.
"μ " = 12×10^6 lbs. per square inch.
= $12 \times 144 \times 10^6$ lbs. per square foot.
"g = 32.2.

"For a tube (ship) 400 ft. long we get from equation (17)

$$\text{“}T = 400\sqrt{n}\sqrt{\frac{500}{32.2 \times 12 \times 144 \times 10^6}} = .03792\sqrt{n}.$$

"If N = the number of vibrations per minute—

$$\text{“}N = \frac{60}{.03792\sqrt{n}} = \frac{1582}{\sqrt{n}}. \qquad (18)$$

"In a ship 400 ft. long, 112.5 may be taken as near the highest number of revolutions of any engine which will be put in it, even if it is a warship. The number of the synchronizing period then is—

$$\text{“}S = \frac{1{,}582}{112.5\sqrt{n}}. \qquad (19)$$

"We thus get the following table:

"n = multiplier for moment of inertia	2	3	4
"N = number of vibrations per min., equation (18)	1,119	913	791
"S = number of synchronizing period, eq. (19)	9.9	8.1	7.0"

Mr. MacAlpine finds that for several other sections the results do not change much from the above. What is required to make a torsionally stiff structure is to so stiffen it that the sections can change shape but very slightly when the twisting couple is applied. This is amply done in a ship by means of the frames, beams, and bulkheads; so we may be sure the above result does not differ greatly from the truth for a ship. Especially is this the case since the time of one vibration lengthens in the same proportion as the square root of the elastic reaction diminishes. We see, then, that the proportionate change in the period is much smaller than that of the elastic reaction. The cylinders being arranged in pairs athwartship, the intensities of the torsion couples due to inertia are changed from those of the ordinary design. Mr. MacAlpine calculates the increase from that of second period upward over what it would be for the same two cylinders placed over the shaft; that is the increase due to the displacement athwartship. The results are:

Period.	Percentage increase.
2d	25.7
3d	0
4th	7
5th	0
6th	3.4
7th	0
etc.	etc.

In his paper it is shown that the synchronizing period will be somewhere in the neighborhood of the seventh to the tenth, and the results just given show that there will be no increase of the tendency to set up elastic torsional vibrations of these periods in this engine over what we have in the ordinary four-crank engine. Hence, we need not fear these vibrations, as they do not occur with the ordinary engine. There is a very large unbalanced first-period inertia torsional couple produced by this engine, which scarcely exists in the direct-connected engine. It will produce no elastic torsional vibrations, as it is only applied from a seventh to a tenth as quick as the lowest of these vibrations, but it will rotate the ship as a rigid body. As, for instance, if we suspend a watch by a thread with its face horizontal, the vibration of the balance wheel would produce a very small vibration of the whole watch. These are not elastic vibrations, but vibrations of a rigid body. Their extent can readily be determined if we know the angular swing and moment of inertia of the balance wheel, and

also the moment of inertia of the whole watch; for the moment of momentum of the whole watch, including the balance wheel, must remain zero. This is well known to everyone, and it holds also with the ship and engine.

Now suppose the connecting rod infinite in length, the velocity of the pistons will be greatest at the center of their travel. Using the same symbols as before, the velocity at the middle of the stroke is wr, and the momentum for the moving masses of one cylinder is mwr. To simplify the explanation, suppose we are dealing with the H.P. and second I.P. which are connected by a lever. m is the same for each as the counterbalance and the parts it balances produce no torsional couple, and so may be omitted. Mwr is, then, the same for both cylinders, the centers of which stand at a distance D from one another. Take the moment of momentum about a point in the center line of the H.P. cylinder. The moment for the H.P. itself is then zero as the lever arm is zero. That for the second I.P. is mwr D. If we took the moment about a point in the plane of the cylinder center lines, at a distance a from that of the H.P., we would have:

$$\begin{aligned} \text{For the P.H. moment} &= mwr \times a \\ \text{For the second I.P. moment} &= mwr \times (D - a) \\ \text{Total moment} &= mwr \times D. \end{aligned}$$

Thus the value of the moment does not change with the position of the point around which we take it. If ρ is the distance of any small mass M of the ship from the axis around which it revolves torsionally, and ψ_1 is the greatest angle by which it departs from its undisturbed position, the linear displacement of M from its mean position has a maximum value $\rho\psi_1$ and the velocity with which it passes through its mean position is $\rho\psi_1 w$, since the vibration is of the same period as the engine revolution. The greates momentum is, then, M$\rho\psi_1 w$, and the moment of momentum M$\rho\psi_1 w \times \rho = M\rho^2\psi_1 w$. For the whole ship this moment of momentum becomes $\psi_1 w\Sigma M\rho^2 = \psi_1 wI$ where I is the moment of inertia of the ship about the longitudinal axis for these vibrations If the total moment of momentum of engine and ship is to be zero they must oppose one another, and we must have

$$\psi_1 I = mwrD$$

or

$$\psi_1 = \frac{mrD}{I}. \qquad (20)$$

The linear amplitude of this vibration will be greater the further we are from the axis. At the side of the ship it will be

$$\psi_1 b = \frac{mrDb}{I}, \qquad (21)$$

where b is the half breadth of the ship.

Mr. MacAlpine says that the time of roll of the ship and the action of the water will have no effect on this vibration. While he is right in the first part, I think he is mistaken as to the action of the water. If the sections of the ship were parts of circles in the immersed portions, the ship might vibrate torsionally with almost no disturbance of the water. But in a very full ship a considerable movement of the water would result, and still more if bilge keels were fitted. This action would be roughly equivalent to an increase of the moment of inertia of the ship and thus would diminish, I believe, often to a very considerable extent, this vibration.

Now, from (d), p. 25, we get
m for H.P. and 2d I.P. cylinders = 6,802 lbs. = 3.04 tons.
m for 1st I.P. and L.P. cylinders = 7,556 lbs. = 3.38 tons.

The velocity of the H.P. piston (connecting rod infinite) when the forward crank is ϕ past top stroke is

$$wr \sin \phi$$

and the moment of momentum for the parts attached to this crank,

$$3.04\, wrD \sin \phi.$$

Similarly, since the after crank leads by 90°, its moment of momentum at the same instant is

$$3.38\, wrD \cos \phi.$$

The total moment of momentum for both cranks is:

$$wrD\,(3.04 \sin \phi + 3.38 \cos \phi)$$
$$= (3.04^2 + 3.38^2)^{1/2} \times wrD \sin (\phi + a).$$

Hence in using equations (20) and (21), instead of m we may put $(3.04^2 + 3.38^2)^{1/2}$.

In twin screw ships this effect will at times be doubled, and we will use $2\,(3.04^2 + 3.38^2)^{1/2} = 9.08$ tons.

Mr. MacAlpine calculates the rigid body vibration which twin engines, Figs. 7 to 18, would give the U. S. S. Alabama. Her engines are of about the same power.

Displacement load (draught) = 11,562 tons.

Radius of gyration he guesses as = 30 ft., and it cannot be greatly different.

Then $I = 11562 \times 30^2$.
b = about 36 feet = 36×12 in.
m = 9.08 tons, from above.
r = 2 ft.
D = 6 ft. (actually 5 ft. 10 in.)
Then from equations (20) and (21)

$$\psi_1 = \frac{9.08 \times 2 \times 6}{11{,}562 \times 30^2} = 1.05 \times 10^{-5}$$

$$\psi_1 b = 1.05 \times 10^{-5} \times 36 \times 12 = .0045 \text{ inch.}$$

Total movement at side of ship = $.0045 \times 2 = .009$ in. or less than 1/100 of an inch.

To force home the smallness of this movement he calculates the apparent movement of the sight of a gun on a target three miles distant. This evidently is—

$$\frac{1}{100} \times \frac{3 \times 5280}{36} = 4.4 \text{ inches.}$$

He next shows that the effects of the second and higher period forces in producing rigid body vibrations will be exceedingly small, even in comparison to that of the very small first-period vibration just calculated. Will these effects be increased or diminished as we change the size of the ship? Let us compare two cases where every dimension of ship A is twice that of ship B, machinery as well as ship; boiler pressure and piston speed to remain the same.

Displacement	Ship B = 1/8	of that of Ship A.
Radius of gyration	" 1/2	"
I (=Disp. × radius of gyrat.^{2})	" 1/32	"
r, crank radius	" 1/2	"
D, cyl. centers athwartship	" 1/2	"
m, moving masses (linear dimensions^3)	" 1/8	"
Wetted surface	" 1/4	"
I.H.P. (as cylinder areas)	" 1/4	"
Grate and heating surface	" 1/4	

Hence ψ_1 for ship B

$$= \frac{\frac{1}{8}\,m \times \frac{1}{2}\,r \times \frac{1}{2}\,D}{\frac{1}{32}I} = \frac{mrD}{I} = \psi_1 \text{ for ship A.}$$

Thus ψ_1 is not altered, and the I.H.P. per square foot of wetted surface also remains the same for both ships. Possibly the small ship would have its scantlings rather lighter than in exact proportion to the dimenions of the two ships as supposed, in which case ψ_1 for ship B would be a trifle larger than ψ_1 for ship A. The total linear movement, $2\psi_1 b$, would therefore be little more than half in ship B what it is in ship A. In very high-powered small warships the I.H.P. per square foot of wetted surface might be four, five, or six times as great as in large warships, but an increase such as this would not bring up $2\psi_1 b$, to more than a very minute value, epecially as in the very high-powered boat the engine would be pressed to its greatest limit of piston speed, and the scantlings kept as light as possible—that is, the power would be taken out of as small and as light an engine as practicable, which both go to reduce ψ_1. Also the larger ψ_1 is, the more powerful will be the action of the water in opposing the vibration. Thus, even in this, the worst case, the solution is still quite satisfactory.

MacAlpine finally refers to twin screws with unbalanced engines as forming a much worse case, in which there is usually no noticeable effect and never one of serious magnitude. In support of this statement of his, and as strongly supporting his whole contention, I may add another quotation from Mr. Yarrow's celebrated 1892 paper:

"As a further proof that the vibration is due to the machinery, I may mention that two years ago I made a passage to the United States in one of the very fast twin-screw steamers. I selected a berth in the central portion of the vessel, thinking it a good position for comfort, but the vibration was found to be so excessive that after five days it was scarcely bearable to the passengers whose berths, like my own, were situated at the points of greatest vibration. The vibration was found to vary periodically. When the two low-pressure pistons were descending at the same time it was excessive; but when one low-pressure piston was ascending and the other descending it was entirely neutralized."

Here we have the whole matter brought to a crucial test. Mr. Yarrow's berth being at the center of the vessel was not only at the point of maximum vertical, but also of maximum torsional vibration. No doubt the berth was at the outside of the vessel where the movement from a given angle of torsion would be greatest. The engines were exceedingly far from being balanced, for when acting together they gave rise to vertical vibrations "scarcely bearable." When the vertical forces were exactly counteracting one another, realizing precisely the effect of MacAlpine's proposed engine, but with a greatly exaggerated leverage between the opposing forces, the vibration was "entirely neutralized." The evidence could not be stronger or freer from doubt; and it enhances its value a thousand fold that it was given by an engineer of the highest ability who had been specially studying and experimenting on this very subject for years previously to 1890. If there had been a sensible torsional vibration it would no doubt have been noted. The conditions were entirely favorable to their being set up. The engines would usually run so nearly at the same speed that elastic torsional vibrations would have ample time to reach their maximum development before the favorable phase passed. The rigid body rotation requires no time to grow; it appears at once of such amplitude as will keep the moment of momentum always zero. Yet none was noted though the unbalanced forces and the lever arm between the engines was so large.

In what immediately precedes, it has been stated that with the ordinary engine elastic torsional vibrations do not occur. It may be objected that Herr Schlick, in his 1895 paper, before the Institution of Naval Architects, speaks of elastic torsional vibrations, giving formulas and diagrams. He does not mention the length of ship on which his observations were made, but judging from the engine revolutions (150) one is let to conclude it was not a very large ship. His formula, which is equivalent to equation (17), would probably have given not less than 1,500 vibrations per minute. He omits to give a numerical example. But his diagrams of torsional (?) vibrations are marked 150 per minute. Mr. Mallock, in the discussion, calls his attention to the great discrepancy between the calculated and observed periods. Herr Schlick's reply is entirely unsatisfactory. He says the difference is due to the small torsional rigidity of the steel hull. "Every ship builder," he says, "knows that the rigidity of a ship's hull against torsion is relatively small." To reduce torsional vibrations from 1,500 to 150 per minute would require a reduction of torsional rigidity in the proportion $\left(\frac{150}{1500}\right)^2 = \frac{1}{100}$!

As the ship was a German war vessel, it would have a steel deck, and, consequently, a torsional rigidity more nearly 80 or 90 per cent. of the corresponding steel tube. I have little doubt that what Herr Schlick observed was the first period rigid body rotation spoken of above. I regret very much that in this discussion I have been compelled to point out what I consider errors in Herr Schlick's papers, and I do not wish in any way to detract from the great credit which is due him for the original work he has done in the study of hull vibration and engine balancing. I am sure that if he were present he would appreciate that these criticisms are really a tribute to the prominent position which he occupies in connection with this subject, and that they simply represent an honest

difference of opinion. That there should be errors in observations and deductions connected with such a complicated subject, is no cause for surprise, and does not, in my judgment, in any way detract from the credit due him.

In what I have written I have tried to include all that has been carried out practically in engine balancing, which can be regarded as any approach toward the solution of the problem. Of the theory I have given enough to exhibit the exact nature of the problem, and have shown that the indications of theory are fully borne out by the consequent phenomena of ship vibrations. I have shown that the old counterbalancing took much too narrow a view. It was adopted long before the exact nature of the forces had been fully investigated, and it can only be looked on as a first approximation to a solution. The discussion has also, I believe, made it clear that the Y. S. T. system is only a partial solution of the balancing problem, and that while it may annul the unbalanced horizontal forces, the effects of which never gave rise to very special remark, it gives an engine in which some of the forces left unbalanced exert very nearly their highest possible effect. With this view of the system, it would have ben out of place in an already very long paper to give the numerous methods, algebraic and semi-graphical, which have been proposed to determine crank angles and moving masses. The engine is costly, heavy, and on account of the calculations required, troublesome to design. When completed it is only a partial solution of the problem, and for the conditions of the fast vessels and high-speed engines of today the solution is far from sufficient. I have shown fully how five and six-crank engines must be adjusted to produce a balance up to the fourth period. That this engine, occupying much valuable space, complex and costly, should have been introduced, even in a few cases, shows how pressing is the necessity for a more complete solution of the balancing problem.

As I stated in the beginning, it is my belief that the MacAlpine system is the best solution of the problem of engine balancing to prevent hull vibration that has thus far appeared. For this reason I have placed in strong contrast the features of this and the Y. S. T. system, inasmuch as the latter has been applied in more cases than any other system which claimed to give a reasonably complete solution of the problem. The discussion has aimed to show that the MacAlpine system considers fully the dynamical problem, and gives a complete solution; that it makes no unwarrantable, even if approximate, assumptions. It has been shown that the lack of complete torsional balance leads to very slight response from the ship, and that this single omission to secure absolutely perfect balance is fully justified, as the advantages gained through the admission of this slight lack of balance very much more than offset the disadvantages. It is to be particularly remarked that the engine which thus realizes the perfect solution of the balancing problem is a perfectly practicable one. It is of a type in common use, and with the performances of which we are perfectly familiar, to which are now added, however, the necessary condition for the solution of this great problem. It has the additional advantages of great compactness, simplicity, and accessibility. If the discussion which has been given should, as I hope, prove conclusive, I trust that the gentleman who has encouraged the preparation of this paper, and who, if I am correctly informed as to his identity, is fully able to test the MacAlpine system, will do so. After a most careful study I am convinced that the system is correct, and I believe the results will amply compensate him for having given it an opportunity for demonstration.

NEW YORK'S GREAT CHANNEL TO THE SEA.

Some figures recently published regarding the work of providing a channel of 40 ft. depth from New York to the sea, show the wonderful progress that has been made of late in constructing high-powered suction dredges. The dredges Thomas and Mills, built at Sparrows' Point, Md., some time ago, and constructed especially for the New York channel contract, have already succeeded in excavating a mile of the channel to a depth of 42 ft. and a width of 2,000 ft. The depth of water over this mile of new channel before dredging began was 14 to 18 ft. The dredges work night and day and in every hour and twenty minutes each of them, working over a reach of 1,000 ft. width, sucks up 4,700 tons of sand. Capt. A. B. Connor, the superintendent in charge, commends in the highest terms the use of Pintsch gas buoys in prosecuting work of this kind by night. He says it would be almost impossible to carry on the work by night without the gas buoys. Six of them are used, three on each side of the channel, and their greatest advantage is their reliability. They are of the kind that can be charged to burn for a very long period—several months—and can always be depended upon. The electric lights on Gedney's channel have, on the contrary, Capt. Connor says, gone out several times while the dredging job has been under way.

TRADE NOTES.

Elisha Webb & Son, Philadelphia, have recently completed the equipment of the tugs Vigilant and Anna W., built at Neafie & Levy's yard, Philadelphia, and the Patience, built at John H. Dialogue & Son's yard, Camden, N. J. They are now fitting out the steamer Springfield, building for the Bordentown & Philadelphia Transportation Co. at Pusey & Jones' yard, Wilmington, Del. They are also in receipt of the order for cooking apparatus for two large freighters building at the Maryland Steel Co.'s works, Sparrow's Point, Md.

In the Chicago store of the Boston Woven Hose & Rubber Co., 185-187 La Salle street, a room has been fitted up for the express use of customers and friends who may happen to be in the city. The room contains the daily papers, magazines, writing materials, etc., and the services of a stenographer if required.

Excursion rates to Florida via Baltimore & Ohio R. R. and Washington, D. C., passing through the beautiful cities of the south. Stop over privilege allowed on all round trip tickets. Two fast trains leave Cleveland daily at 3:00 and 11:20 p. m. Call at city ticket office, 241 Superior street. tf.

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Originated 1849 — Latest Improvements 1896

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Year.	Australien	Polynésien	Armand Béhic	Ville de la Ciotat	Ernest Simons	Chili	Cordillère	Laos	Indus	Tonkin	Annam	Atlantique
1890.....	67,728	2,460										
1891.....	68,247	68,331	204									
1892.....	68,247	68,403	69,822	23,259								
1893.....	68,379	68,343	68,286	68,247								
1894.....	68,439	68,367	68,574	68,439	37,701							
1895.....	68,673	68,766	68,739	68,808	40,887	28,713						
1896.....	69,534	92,718	69,696	69,549	62,205	63,153	40,716					
1897.....	68,250	69,606	92,736	69,555	62,235	76,110	63,357	43,146				
1898.....	70,938	69,534	69,552	69,597	62,526	63,240	63,240	62,553	63,954	22,707		
1899.....	69,534	69,615	67,431	90,405	60,246	62,778	62,868	52,344	54,855	44,007	22,884	
1900.....	69,534	67,494	69,744	69,564	61,719	62,382	62,502	51,471	53,373	62,016	63,066	52,140
Total.....	757,503	713,637	644,784	597,423	387,519	356,376	292,683	209,514	172,182	128,730	85,950	52,140

ATELIERS ET CHANTIERS DE L'ERMITAGE, À ST. DENIS (SEINE), FRANCE.
WORKS AND YARDS OF L'ERMITAGE AT ST. DENIS (SEINE), FRANCE.
TELEGRAPHIC ADDRESS: BELLEVILLE, SAINT-DENIS-SUR-SEINE.

ITEMS OF GENERAL INTEREST.

The battleship Illinois has reached New Orleans and will be the first vessel to be docked in the new Algiers dry dock. The city of New Orleans is preparing to make a gala day out of the event.

English newspapers are predicting a reduction in wages and other operating expenses on ships. The effect of the boom in shipping having now entirely passed away, ship owners who have recently placed orders for new tonnage regret that they have done so, and in many instances are negotiating for delay in delivery, owing to the unprofitable state of the freight market.

The Rainy River Navigation Co., Rat Portage, Ont., has completed a profitable season and all the steamers are in winter quarters. The Keenora, Agwinde, Edna Brydges and Maple Leaf are laid up at Rat Portage and the Majestic, City of Alberton and Undine at Fort Frances. The Canadian Northern Railway from Port Arthur to Winnipeg is nearing completion and it is expected that the development of the fine farming lands along the Rainy river will greatly add to the steamboat business on the river.

Miller, Thornburgh & Co., incorporated under the laws of New York, with offices at 135 to 137 Broadway, New York city, will engage in the iron and steel business, making a specialty of wrought iron pipe, cold drawn seamless, lapweld steel and charcoal iron boiler tubes, rivets, etc. The above concern is composed of the following gentlemen: President, W. E. Miller, formerly president of Shelby Steel Tube Co.; vice-president and manager, L. B. Thornburgh, formerly assistant general sales agent of Shelby Steel Tube Co.; secretary, E. A. Miller, formerly New England representative of Shelby Steel Tube Co.; treasurer, A. A. Kaiser, formerly New York representative of Shelby Steel Tube Co.

Admiral Farragut's famous old flagship, the Hartford, now a training vessel, commanded by Capt. Joseph Hawley, has arrived at Hampton Roads, after a cruise in European and West Indian waters, spent in instructing 400 landsmen in the duties of regular sailors. The Hartford will go to the New York navy yard to be overhauled extensively. Meanwhile, the auxiliary cruiser Prairie will be commissioned at the New York yard as a training ship and will take out another big crew of landsmen. The success of the experiment of augmenting the enlisted force of the navy by grown men of American birth, without regard to any previous experience on the sea, has been demonstrated and is regarded as of greater and surer benefit to the service than the slower system of training boys.

The special investigation of torpedo boats and torpedo boat destroyers projected to see that these vessels were fitted out in a manner satisfactory for sea service, and so as to avoid the carrying of unnecessary weights, has been concluded. When Admiral Bowles took charge of the construction bureau and began to examine the torpedo boats in course of construction in the various yards he found much that did not satisfy him, and he concluded to have a line officer who had had practical experience with torpedo boats, and a naval constructor, undertake a systematic inquiry. Lieut. Lloyd H. Chandler of the torpedo boat Bailey, who has given this subject special study, and Naval Constructor Linnard, were accordingly selected. They have made an inspection of all the torpedo boats and destroyers that are under construction except those on the Pacific coast.

Emperor William of Germany attended the recent meeting of the Society of Naval Engineers at Charlottenberg. He exhibited great interest throughout, especially applauding the remarks of Herr Meyer, a shipbuilder of Papenburg, who explained how, in his opinion, foreign shipbuilding competition, especially American competition, could best be circumvented. Herr Meyer deprecated the continually increasing number of yards, insisting that attention should rather be devoted to enlarging and perfecting the existing establishments. He held that a part of the yearly profits should be employed in obtaining the services of specially trained and skilled workmen. Once this is attained, said he, the Germans could calmly contemplate foreign competition and look upon the "American spectre" with perfect equanimity, for "the Germans would be found to be the victors." Herr Meyer's remarks were followed by an address made by Councillor Schwarz of the ministry of marine, relating to the development of American ship building during the last decade.

A number of very complete outfits of driving machinery and boat equipment, accompanied by plans and specifications for building the hull and installing the machinery, have been sent out by the Marine Iron Works, station A, Chicago. Several similar contracts now under way. This is a plan that they have demonstrated to be an exceptionally good one, particularly for those located at a distance where they may have suitable material and good men to do the work, provided they secured the necessary information with plans and details, all of which the Marine Iron Works furnish with their complete machinery outfits when so contracted for. 3

A chart of Lake Erie in colors (engineer survey) has just been issued and may be had from the Marine Review.

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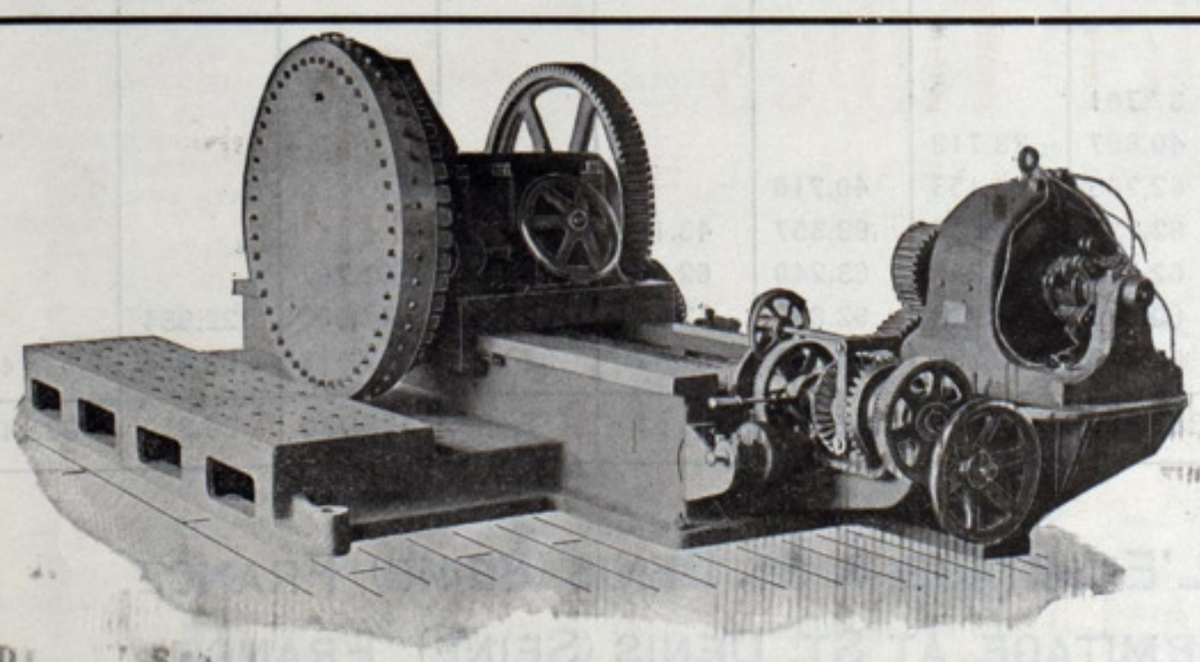

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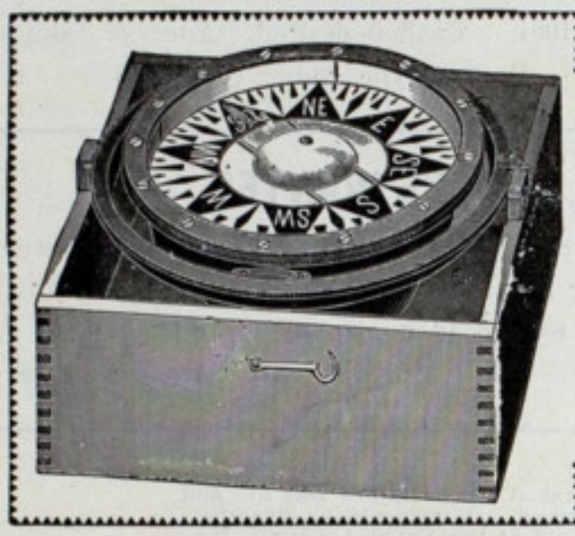

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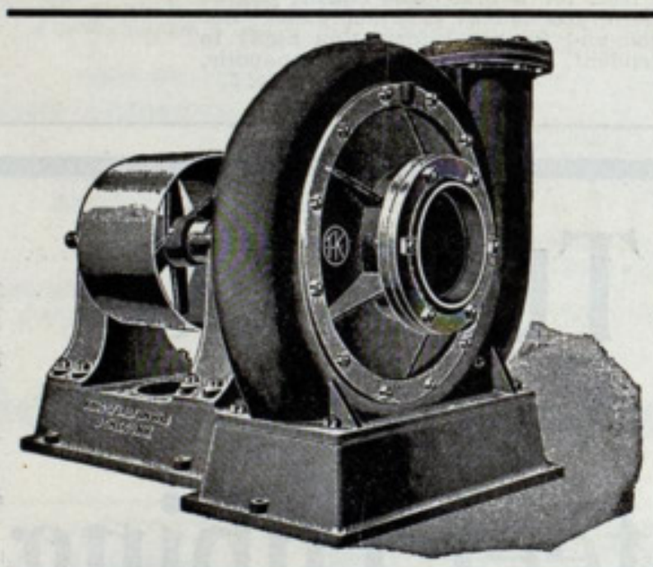

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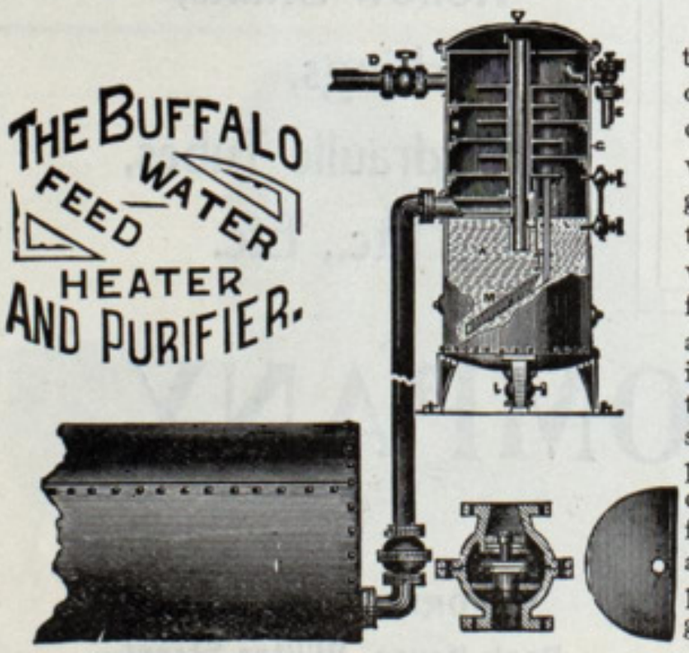

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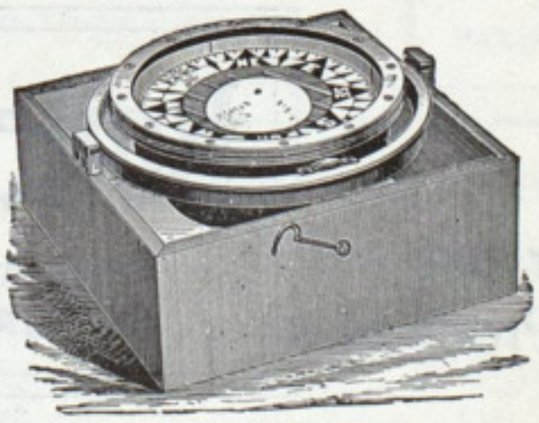

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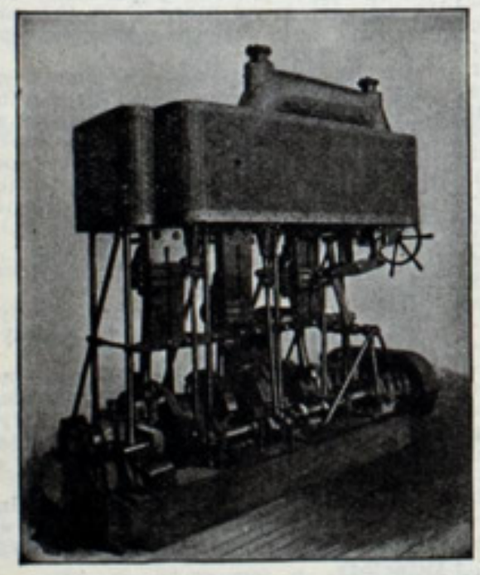

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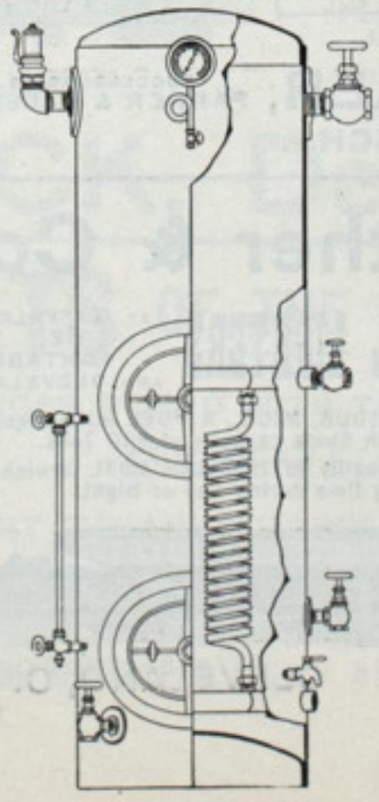

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Niles Tool Works Co.....Hamilton, O.
Wood & Co., R. D.....Philadelphia.

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Standard Pneumatic Tool Co.....Chicago.

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Bertram's Oil Polish Co.....Boston.

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"Long Arm" System Co.....Cleveland.

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Cramp, Wm. & Sons.....Philadelphia.
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Farrar & Trefts.....Buffalo.
Fore River Ship & Engine Co.....Quincy, Mass.
Hardy, John B.....Tacoma, Wash.
Hyde Windlass Co.....Bath, Me.
Harlan & Hollingsworth Co.....Wilmington, Del.
Hodge, S. F. & Co.....Detroit.
Jenks Ship Building Co.....Port Huron, Mich.
Lockwood Mnfg. Co.....East Boston, Mass.
MacKinnon Mfg. Co.....Bay City, Mich.
Maryland Steel Co.....Sparrow's Point, Md.
Moran Bros. Co.....Seattle, Wash.
Neafie & Levy Ship & Engine Bldg. Co.....Philadelphia.
Newport News Ship Building Co.....Newport News, Va.
Nixon, Lewis.....Elizabeth, N. J.
Phosphor Bronze Smelting Co., Ltd.....Philadelphia.
Pusey & Jones Co.....Wilmington, Del.
Risdon Iron Works.....San Francisco.
Roelker, H. B.....New York.
Sheriffs Mnfg. Co.....Milwaukee.
Standard Ship Building Co.....Perth Amboy, N. J.
Trigg, Wm. R. Co.....Richmond, Va.
Trout, H. G.....Buffalo.

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Badt-Goltz Engineering Co.....Chicago.
Elwell-Parker Electric Co.....Cleveland.
Fort Wayne Electric Works.....Fort Wayne, Ind.
General Electric Co.....Schenectady, N. Y.
Rushmore Dynamo Works.....Jersey City, N. J.
Seidler-Miner Electric Co.....Detroit.
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Wood, R. D. & Co.....Philadelphia.
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Niles Tool Works Co.....Hamilton, O.
Wood, R. D. & Co.....Philadelphia.

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Great Lakes Register.....Cleveland.

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Bourne-Fuller Co.....Cleveland.
Champion Rivet Co.....Cleveland.

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Ashton Valve Co.....Boston.
Crosby Steam Gage & Valve Co.....Boston.

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Baker, Howard H. & Co.....Buffalo.
Upson-Walton Co.....Cleveland.
Wilson & Silsby.....Boston.

SALVAGE COMPANIES.
See wrecking companies.

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Badt-Goltz Engineering Co.....Chicago.
Elwell-Parker Electric Co.....Cleveland.
Fort Wayne Electric Works.....Fort Wayne, Ind.
General Electric Co.....Schenectady, N. Y.
Rushmore Dynamo Works.....Jersey City, N. J.
Seidler-Miner Electric Co.....Detroit.
Westinghouse Electric & Mnfg. Co.....Pittsburg.

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Bement, Miles & Co.....Philadelphia.
Niles Tool Works Co.....Hamilton, O.
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Bourne-Fuller Co.....Cleveland.

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American Ship Building Co.....Cleveland.
Atlantic Works.....East Boston, Mass.
Bath Iron Works, Ltd.....Bath, Me.
Buffalo Dry Dock Co.....Buffalo.
Cramp, Wm. & Sons.....Philadelphia.
Craig Ship Building Co.....Toledo, O.
Chicago Ship Building Co.....Chicago.
Detroit Shipbuilding Co.....Detroit.
Fore River Ship & Engine Co.....Quincy, Mass.
Hardy, John B.....Tacoma, Wash.
Harlan & Hollingsworth Co.....Wilmington, Del.
Jenks Ship Building Co.....Port Huron, Mich.
Lockwood Mnfg. Co.....East Boston, Mass.
Maryland Steel Co.....Sparrow's Point, Md.
Moran Bros. Co.....Seattle, Wash.
Neafie & Levy Ship & Engine Bldg. Co.....Philadelphia.
Newport News Ship Building Co.....Newport News, Va.
Nixon, Lewis.....Elizabeth, N. J.
Pusey & Jones Co.....Wilmington, Del.
Risdon Iron Works.....San Francisco.
Roach's Ship Yard.....Chester, Pa.
Standard Ship Building Co.....Perth Amboy, N. J.
Trigg, Wm. R. Co.....Richmond, Va.
Willard, Chas. P. & Co.....Chicago.

SHIP CHANDLERS.
Baker, Howard H. & Co.....Buffalo.
Moran Bros. Co.....Seattle, Wash.
Reilly Repair & Supply Co., James.....New York.
Upson-Walton Co.....Cleveland.

BUYERS' DIRECTORY OF THE MARINE TRADE.—Continued.

SOUNDING APPARATUS.
Farr, C. W.....Chicago.

SPARS—LARGE SIZES.
Moran Bros. Co.....Seattle, Wash.

STAYBOLTS, IRON OR STEEL, HOLLOW OR SOLID.
Falls Hollow Staybolt Co.....Cuyahoga Falls, O.

STEAM VESSEL FOR SALE.
Holmes, Samuel.....New York.

STEAMSHIP LINES, PASS. AND FREIGHT.
American Line.....New York.
Cleveland & Buffalo Transit Co.....Cleveland.
Clyde Line.....New York.
Dominion Line.....Boston.
Erie & Western Trans. Co.....Buffalo.
International Nav. Co.....Philadelphia.
Red Star Line.....New York.

STEEL CASTINGS.
Seaboard Steel Casting Co.....Chester, Pa.

STEERING APPARATUS.
American Ship Building Co.....Cleveland.
Chase Machine Co.....Cleveland.
Detroit Shipbuilding Co.....Detroit.
Electro-Dynamic Co.....Philadelphia.
Hyde Windlass Co.....Bath, Me.
Jenks Ship Building Co.....Port Huron, Mich.
Queen City Engineering Co.....Buffalo.
Sheriffs Mnfg. Co.....Milwaukee.

STOCKS, BONDS, SECURITIES.
Wright, Herbert & Co.....Cleveland.

STOCKLESS ANCHORS.
Baldt Anchor Co.....Chester, Pa.
International Anchor Co.....Cleveland.

SUBMARINE DIVING APPARATUS.
Hale Rubber Co., Alfred.....So. Boston, Mass.
Schrader's Son, A.....New York.

SURVEYORS, MARINE.
Holmer & Goodenough.....New York.
Gaskin, Edward.....Buffalo.
See, Horace.....New York.
Wood, W. J.....Chicago.

TELEGRAPH—DECK AND ENGINE ROOM.
Cory, Chas. & Son.....New York.

TESTS OF MATERIAL.
Hunt, Robert W. & Co.....Chicago.
Pittsburgh Testing Laboratory, Ltd.....Pittsburg.

THERMOMETERS FOR MECHANICAL PURPOSES.
Helios-Upton Co.....Peabody, Mass.

TOOLS, METAL WORKING, FOR SHIP AND ENGINE WORKS.
Bement, Miles & Co.....Philadelphia.
Cleveland Punch & Shear Works Co.....Cleveland.
New Doty Mnfg. Co.....Janesville, Wis.
Niles Tool Works Co.....Hamilton, O.
Pond Machine Tool Co.....Plainfield, N. J.
Pratt & Whitney Co.....Hartford, Conn.
Standard Pneumatic Tool Co.....Chicago.
Watson-Stillman Co.....New York.
Wood, R. D. & Co.....Philadelphia.

TOOLS, WOOD WORKING.
Atlantic Works, Inc.....Philadelphia.

TOWING MACHINES.
American Ship Windlass Co.....Providence, R. I.
Chase Machine Co.....Cleveland.

TOWING COMPANIES.
Donnelly Salvage & Wrecking Co.....Kingston, Ont.
Midland Towing & Wrecking Co., Ltd.....Midland, Ont.
Swain Wrecking Co.....Detroit.

TRAPS, STEAM.
D'Este Co., Julian.....Boston.
Haines Co., Wm. S.....Philadelphia.

TRUCKS.
Boston & Lockport Block Co.....Boston.

TUBING, SEAMLESS.
Benedict & Burnham Mnfg. Co.....Waterbury, Conn.
Standard Seamless Tube Co.....Pittsburg.

VALVES, STEAM SPECIALTIES, ETC.
American Steam Gauge Co.....Boston.
Ashton Valve Co.....Boston.
Crane Co.....Chicago.
Crosby Steam Gage & Valve Co.....Boston.
D'Este Co., Julian.....Boston.
Jenkins Bros.....New York.
Wood & Co., R. D.....Philadelphia.

VARNISH PAINT.
Mair, John & Son.....Philadelphia.

VESSEL AND FREIGHT AGENTS.
Boland, John J.....Buffalo.
Brown & Co.....Buffalo.
Chamberlain & Co., S. R.....Chicago.
Drake & Maytham.....Buffalo.
Elphicke, C. W. & Co.....Chicago.
Hall & Root.....Buffalo.
Helm, D. T. & Co.....Duluth, Minn.
Holmes, Samuel.....New York.
Hutchinson & Co.....Cleveland.
Keith, J. G. & Co.....Chicago.
Kennedy, Hunter & Co.....Antwerp.
Mitchell & Co.....Cleveland.
Richardson, W. C.....Cleveland.
Sullivan, D. & Co.....Chicago.
Tandy, Frank N.....Boston.

VENTILATING APPARATUS FOR SHIPS.
American Blower Co.....Detroit.
Boston Blower Co.....Hyde Park, Mass.
Buffalo Forge Co.....Buffalo.
Sturtevant, B. F. Co.....Boston.

WIRE ROPE AND WIRE ROPE FITTINGS.
American Steel & Wire Co.....Chicago.
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Upson-Walton Co.....Cleveland.

WHISTLES, STEAM.
American Steam Gauge Co.....Boston.
Ashton Valve Co.....Boston.
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WINDLASSES.
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American Ship Building Co.....Cleveland.
Hyde Windlass Co.....Bath, Me.
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WINCHES.
American Ship Windlass Co.....Providence, R. I.
Hyde Windlass Co.....Bath, Me.

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Atlantic Works, Inc.....Philadelphia.

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Donnelly Salvage & Wrecking Co.....Kingston, Ont.
Midland Towing & Wrecking Co., Ltd.....Midland, Ont.
Swain Wrecking Co.....Detroit.

YACHT SAILS, FITTINGS, HARDWARE, ETC.
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No. 28,	New York & Boston Express	*7 40 am	*8 00 am
No. 40,	Toledo & Buffalo Accom.	†10 00 am	†11 40 am
No. 32,	Fast Mail	*11 25 am	*11 30 am
No. 44,	Accommodation, via Sandusky	†1 35 pm	.....
No. 36,	Cleveland & New York Special	.....	*3 00 pm
No. 46,	Southwestern Express	.....	*3 10 pm
No. 6,	Limited Fast Mail	*5 40 pm	*5 45 pm
No. 10,	Chicago, New York & Boston Special	*7 35 pm	*7 45 pm
No. 16,	New England Express	*10 30 pm	*10 35 pm
No. 2,	Day Express	†9 05 pm	†9 20 pm
No. 126,	Norwalk Accommodation	†7 55 am	.....
No. 40,	Toledo & Buffalo Accom., via Norwalk	†10 00 am	†11 40 am
No. 106,	Conneaut Accommodation	.....	†4 30 pm
	Westward:—	Ar. fr. East.	Dep. West.
No. 11,	Southwestern Limited	*3 25 am	.....
No. 15,	New York, Boston & Chicago Special	*3 05 am	*3 10 am
No. 21,	New York & Chicago Express	*5 10 am	*5 20 am
No. 7,	Day Express	.....	†6 30 am
No. 19,	The Lake Shore Limited	*7 35 am	*7 40 am
No. 23,	Western Express	*11 10 am	*11 15 am
No. 33,	Southwestern Express	*12 25 pm	.....
No. 133,	Cleveland & Detroit Express	.....	*12 45 pm
No. 47,	Accommodation	.....	†3 00 pm
No. 141,	Sandusky Accommodation	.....	†3 10 pm
No. 127,	Norwalk Accommodation	.....	†5 10 pm
No. 37,	Pacific Express	*7 00 pm	*7 20 pm
No. 25,	Southern Express	*9 30 pm	.....
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Lv. DAYTON, Daily except Sunday	6:12 p. m.
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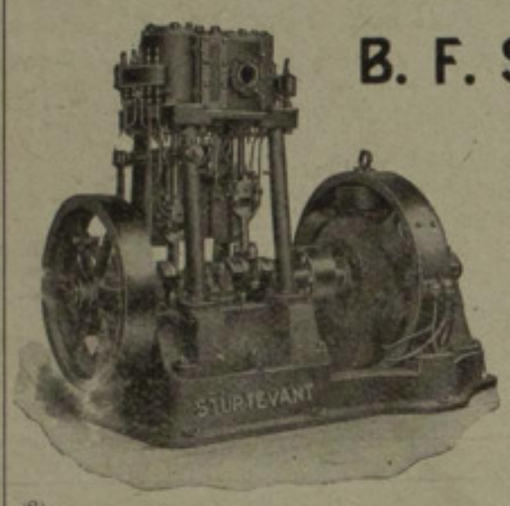

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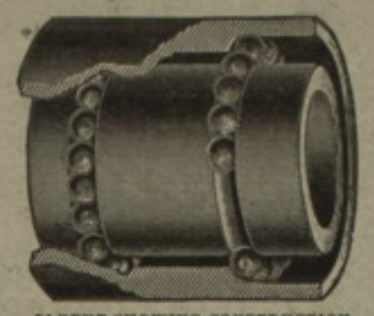

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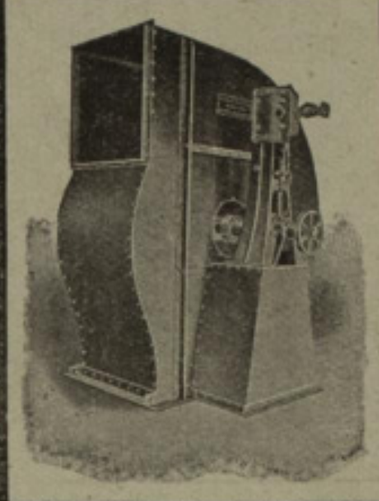

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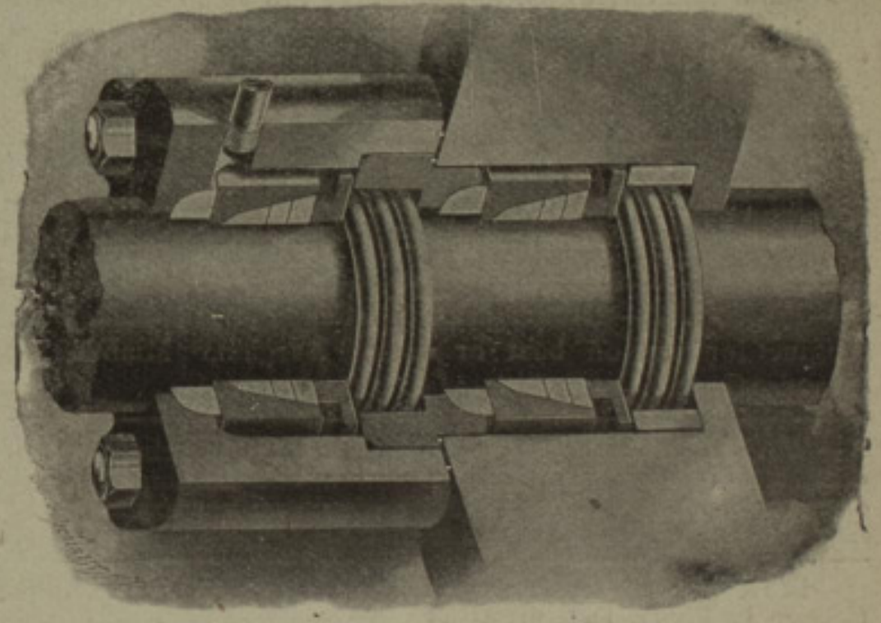

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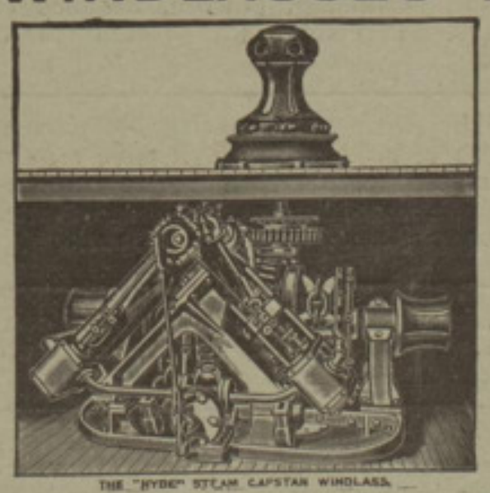

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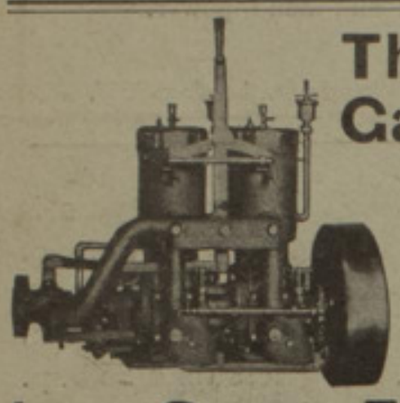

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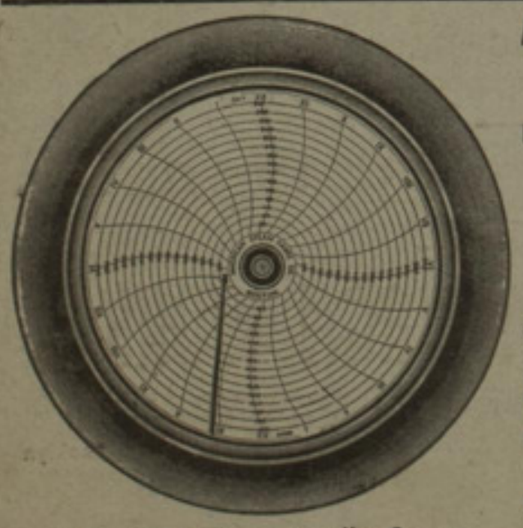

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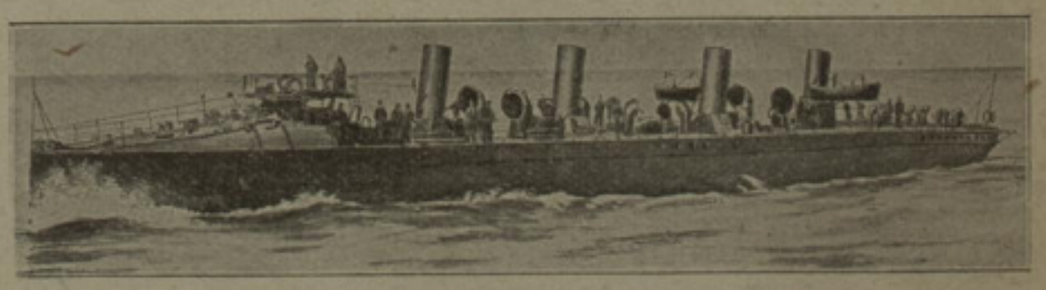

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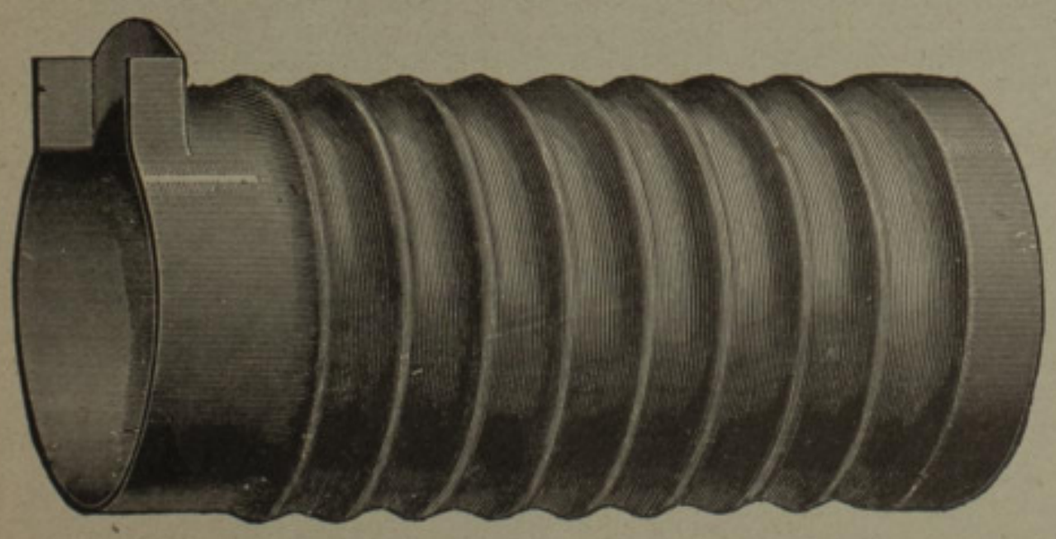

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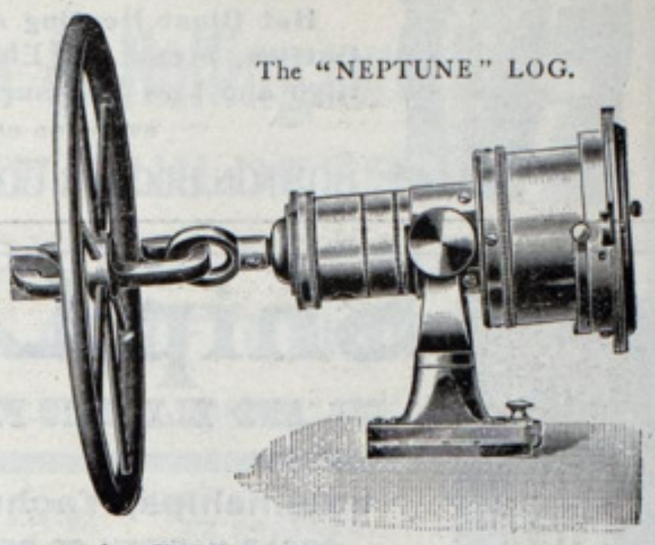

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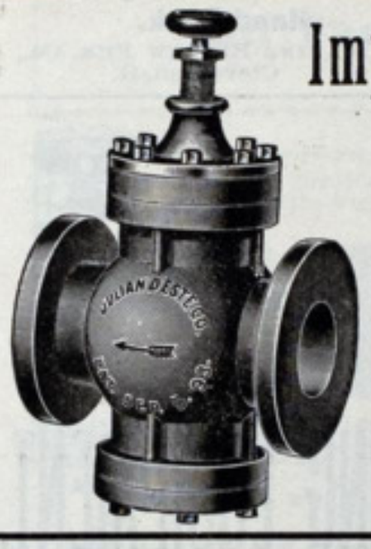

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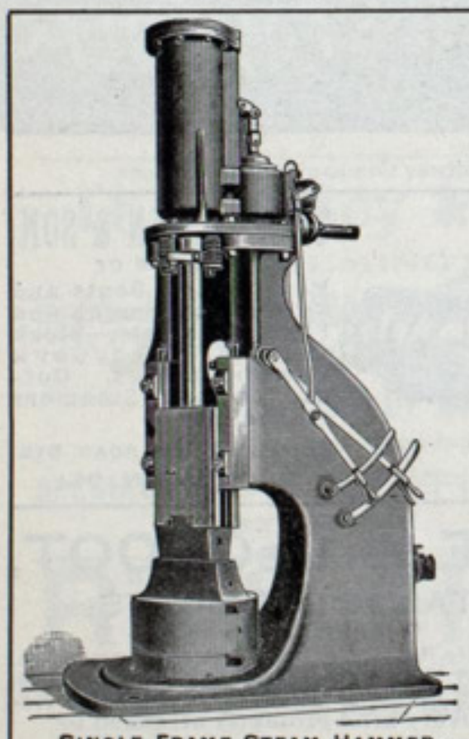

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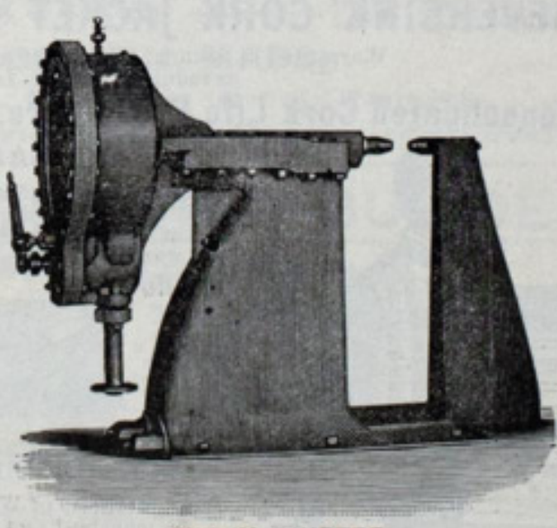

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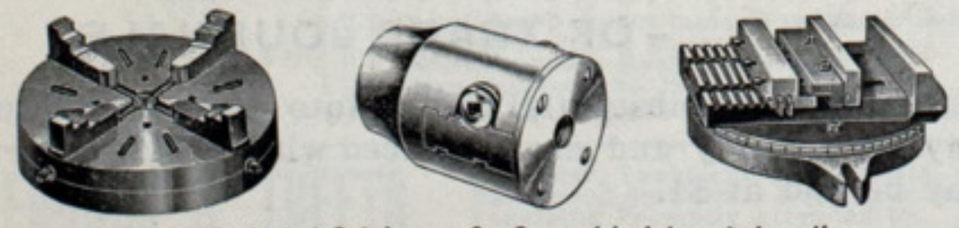

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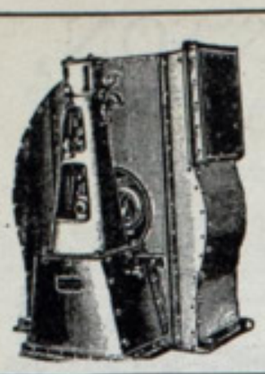

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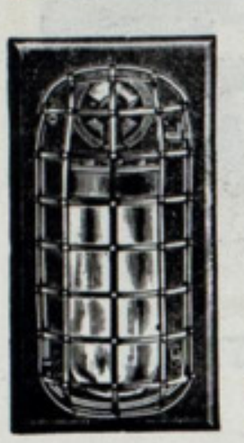

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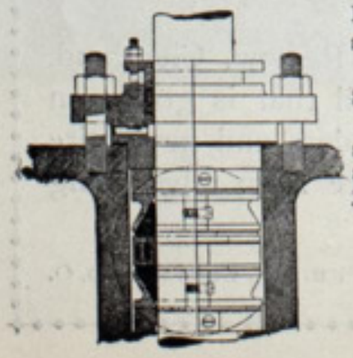

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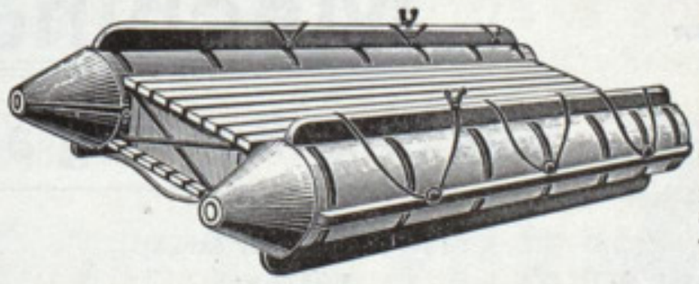

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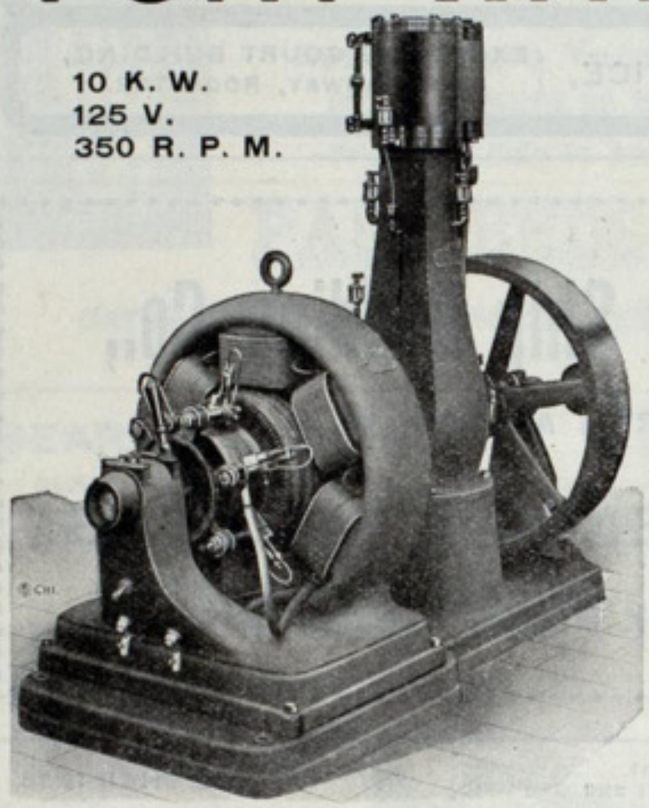

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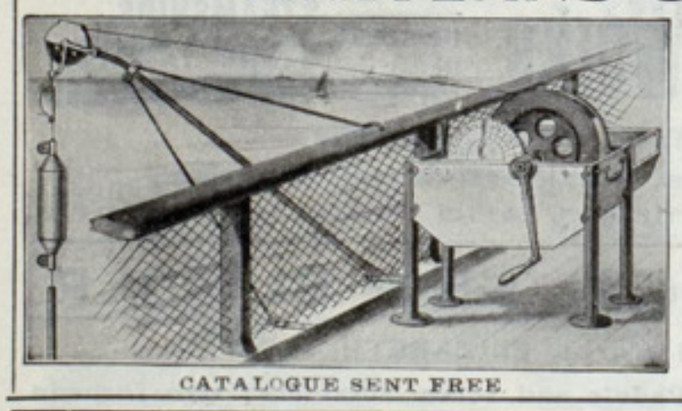

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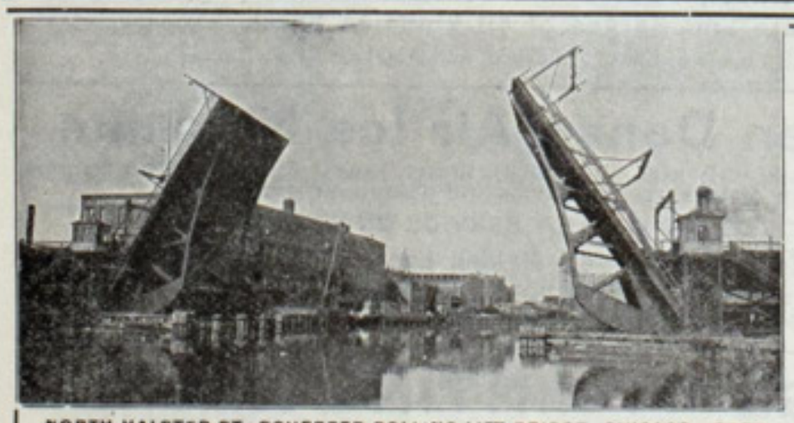

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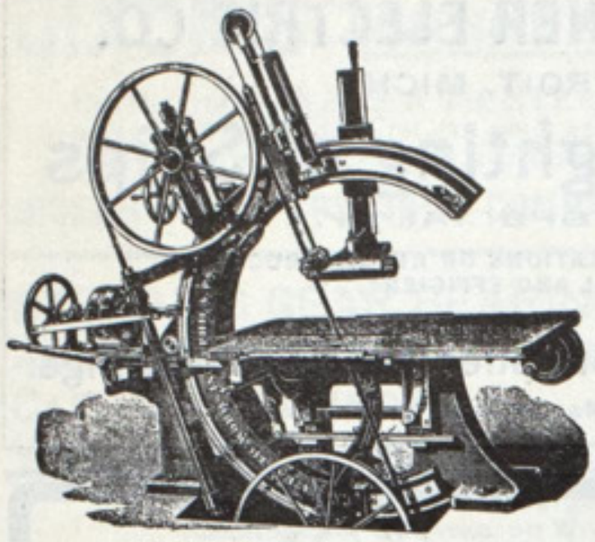

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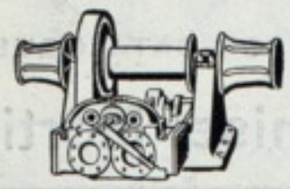

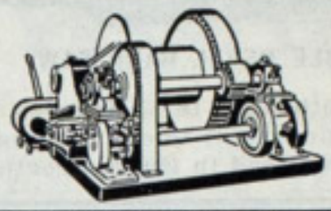

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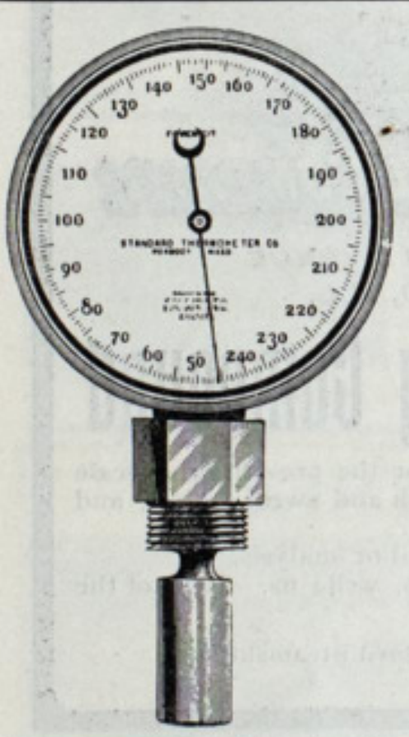

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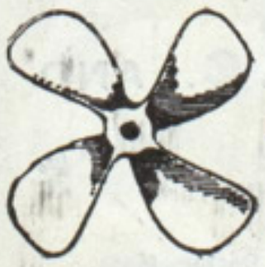

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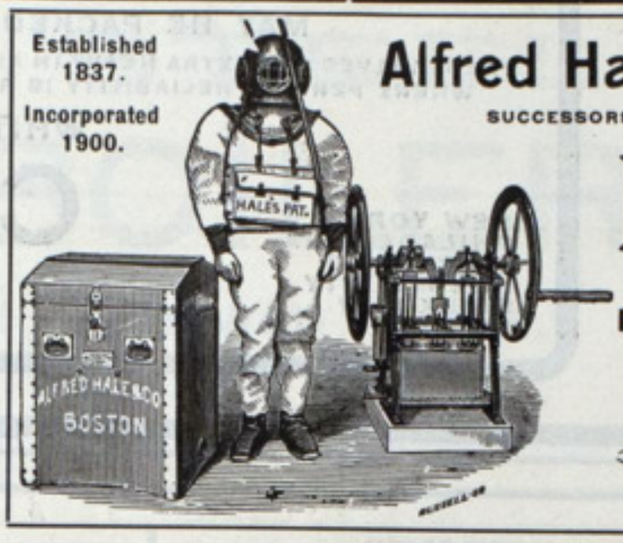

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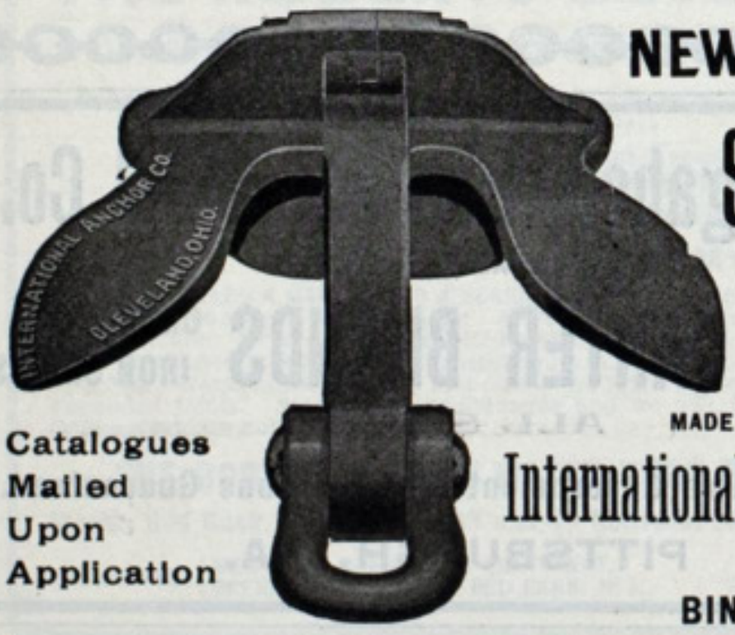

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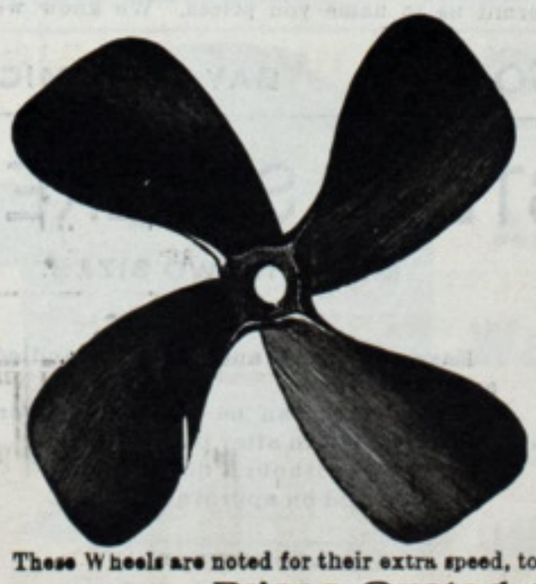

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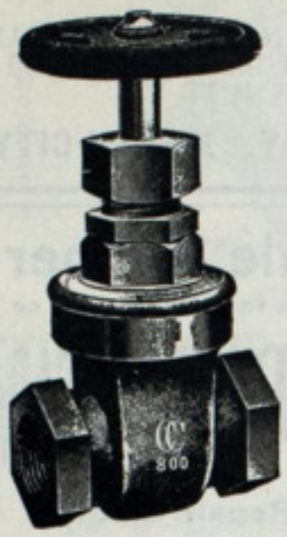

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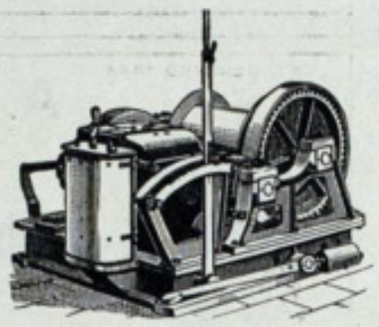

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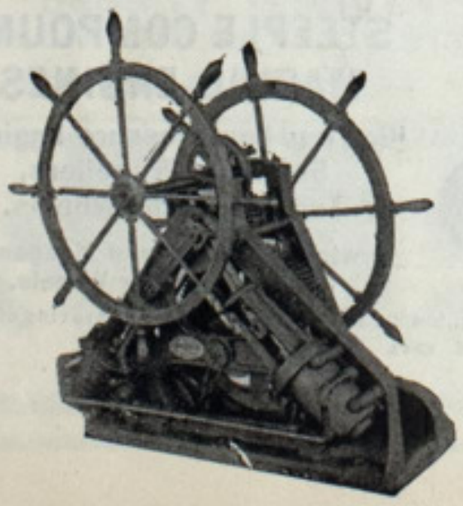

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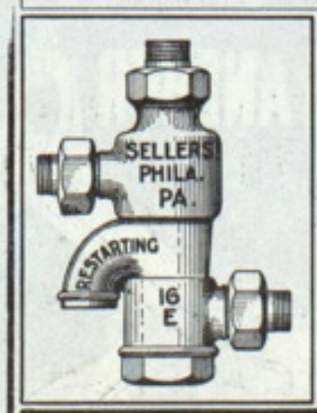

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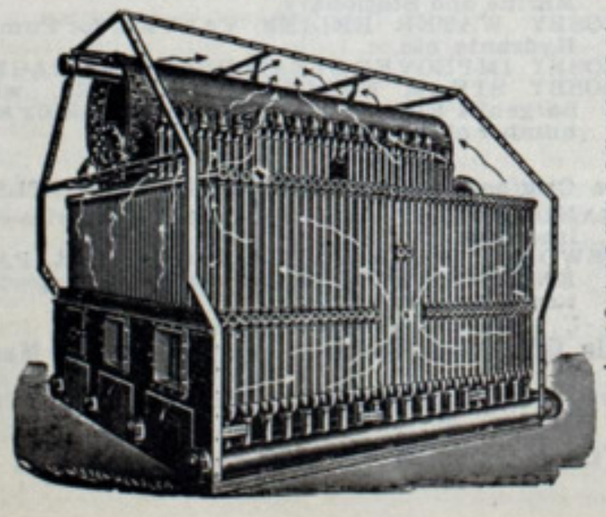

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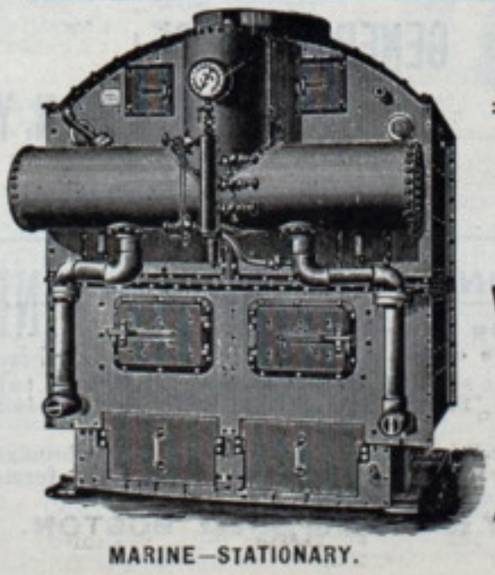

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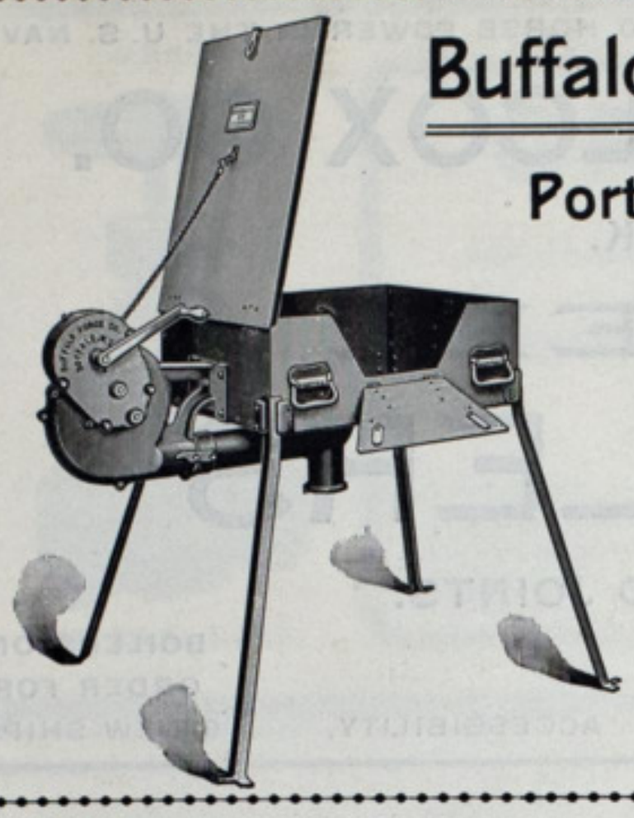

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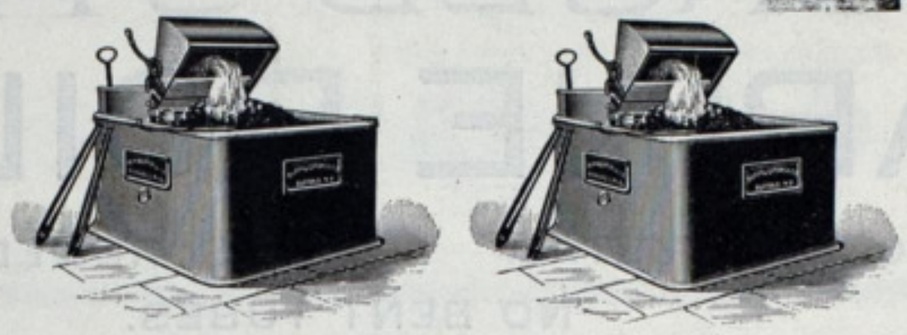

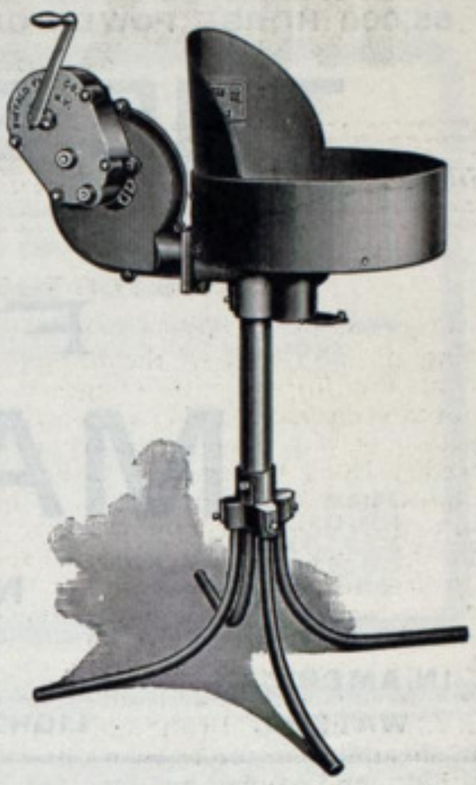

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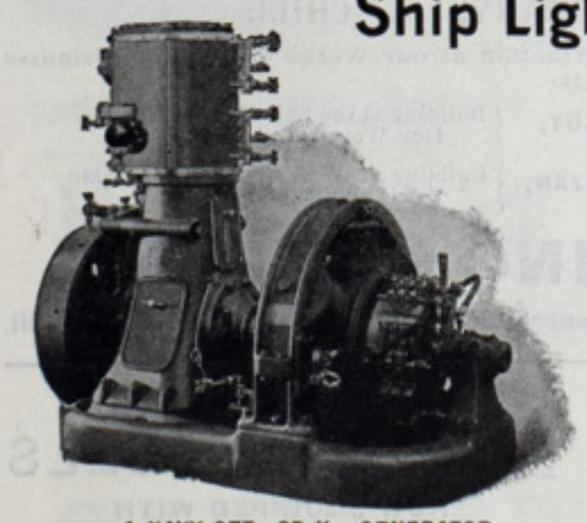

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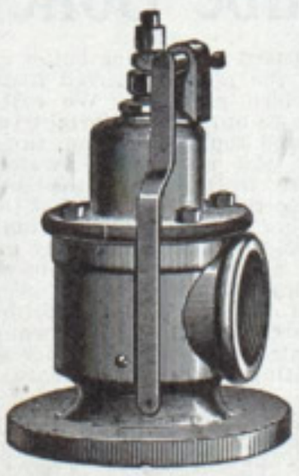

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